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Improving Laundry Plant Energy Efficiency

A Study Done for the Department of Defense

by
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To comply with Presidential Executive Order 12759, which requires federal facilities to increase industrial/ process energy efficiency 20 percent by the fiscal year 2000 (FY00) in comparison with FY85, the Department of Defense must improve the efficiency of its laundry facilities. Army laundry managers presently reduce utility consumption by using setback timers on equipment and lights, disconnecting or disabling unused equipment, installing occupancy sensors in seldom-used areas, and replacing worn out conventional equipment with more efficient models.

This study surveyed Army laundry facilities to determine and characterize their current condition and utility consumption. Those facilities were compared with commercial facilities of similar size, and alternative facility designs using advanced technologies were developed. This study concluded that it is still in the government's interests to own and operate military laundry facilities. However, to isolate waste and inefficiency, Army laundries must supplement current practices by consistently monitoring their energy and utility consumption. It was also concluded that Army laundry facilities can significantly improve efficiency by adding advanced technologies to increase utility savings by further reducing energy and water consumption, and production costs required to process laundry.

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To comply with Presidential Executive Order 12759, which requires federal facilities to increase industrial/process energy efficiency 20 percent by the fiscal year 2000 (FY00) in comparison with FY85, the Department of Defense must improve the efficiency of its laundry facilities. Army laundry managers presently reduce utility consumption by using setback timers on equipment and lights, disconnecting or disabling unused equipment, installing occupancy sensors in seldom-used areas, and replacing worn out conventional equipment with more efficient models.

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Foreword

This study was conducted for the Office of the Deputy Undersecretary of Defense, Environmental Security, Conservation and Installations under Military Interdepartmental Purchase Request (MIPR) No. DSAM20076, dated 29 March 1993. The technical monitor was Millard Carr, OASD-I(EE).

The work was performed by the Utilities Division (UL-U) of the Utilities and Industrial Operations Laboratory (UL), U.S. Army Construction Engineering Research Laboratories (USACERL). Martin J. Savoie was the USACERL principal investigator. William B. Scholten is associated with Science Applications Information Corporation (SAIC). George A. Williamson is employed by Thompson Engineering & Consulting, Inc. (TEC). Special acknowledgment is given to Claude Rudd, Charles Brown, and Victor Fiol, of HQ, U.S. Army Aviation and Troop Command, Weapon Systems Manager for Clothing and Services, Fort Lee, VA. Special acknowledgment is also given to the Department of Defense (DOD) laundry personnel who helped gather data and provided tours of their laundry facilities. Martin J. Savoie is Acting Chief, CECER-UL-U, John T. Bandy is Operations Chief, and Gary W. Schanche is Chief, CECER-UL. The USACERL technical editor was William J. Wolfe, Technical Resources.

COL James T. Scott is Commander and Acting Director of USACERL, and Dr. Michael J. O'Connor is Technical Director.

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Background

Presidential Executive Order 12759 requires federal facilities to increase industrial/process energy efficiency 20 percent by the year fiscal year 2000 (FY00) in comparison with FY85. Where energy improvements can yield sufficient payback, the Department of Defense (DOD) may help installations fund energy-saving measures through its Energy Conservation Investment Program (ECIP), which is available to installations through the Facility Energy Management Program (FEMP) of each military branch. U.S. Navy facilities have begun to actively acquire state-of-the-art equipment and have already successfully modernized their laundry technologies. U.S. Air Force facilities have responded by contracting out nearly all of their laundry processing. Many U.S. Army facilities, however, have not yet modernized their laundry facilities for several reasons. Army laundry managers often find that established recordkeeping and acquisition procedures can complicate the process of quickly acquiring new equipment to keep their facilities up to date. For example, most Army installations do not meter energy use by individual buildings or utility areas, so Army laundry managers do not receive or have access to utility bills pertaining to their work areas. This makes it impossible to isolate specific incidences of energy overconsumption or waste, and hard to document needed justifications for new equipment purchases.

Most DOD laundry managers express concern with the performance of their operations and a desire to improve the performance and efficiency of their plants. In spite of acknowledged problems associated with outdated equipment and insufficient data, laundry managers presently reduce utility consumption by using setback timers on equipment and lights, disconnecting or disabling unused equipment, installing occupancy sensors in seldom-used areas, and replacing worn out conventional equipment with more efficient models. Army laundry facilities need to supplement these practices by adding advanced technologies to increase utility savings by further reducing energy and water consumption, and to decrease production costs by reducing the amount of labor required to process laundry.

Objectives

The objectives of this study were to: (1) determine and characterize the condition and utility consumption of DOD laundry facilities; (2) compare those facilities with commercial facilities of similar size, and; (3) provide DOD with alternative facility designs using advanced technologies that can increase the efficiency and cost-effectiveness of military laundry operations.

Approach

1. DOD laundry facilities were reviewed and characterized to establish a baseline for operating conditions, utility use, equipment type and condition, and production rates. Project Fact Sheets (surveys) were sent to 28 DOD laundry facilities with data collection forms to determine energy use, annual production, and operating conditions (Appendix A). Survey information was supplemented with site visits to selected DOD laundry facilities.

2. The collected data were entered into a spreadsheet and graphically analyzed.

3. The Science Applications International Corporation (SAIC) was contracted to collect data on commercial laundry facilities and on currently available advanced laundry equipment.

4. SAIC developed models of laundry facilities of the size and type required by DOD. These models provided the basis to compare conventional DOD laundries with commercial facilities using advanced laundry technologies.

5. Based on these comparisons, recommendations were formulated for modernizing DOD laundry facilities to achieve efficiencies in production, energy use, labor, and utility consumption comparable to those in the commercial sector.

Scope

The information gathered in this study applies specifically to DOD laundry facilities. However, the results of this evaluation may also be helpful in equipment selection and operation, and in determining the real potential for utility (energy, water, and sewer) and cost savings in Veterans' Administration and commercial laundry facilities.

Metric Conversion Factors

Metric conversion factors for the U.S. standard units of measure used in this report are given below:

1 cu ft	=	0.028 m^3
1 gal	=	3.78 L
1 lb	=	0.453 kg
1 psi	=	6.89 kPa
°F	=	(°C × 1.8) +32
1 Btu	=	2.928 × 10^{-4} kilowatt hr

2 DOD Laundry Facilities

Typical Plant Overview

In the typical laundry facility (Figure 1*), items are unloaded and then sorted into batches of similar goods. The batches of laundry are then washed in a single-batch or a continuous-batch washer. After the wash cycle is complete, excess water is extracted from the batch. The extraction process can be performed in the washer or in a separate piece of machinery known as an extractor. In the extractor, the goods are either spun or squeezed to drive out excess water before drying. After extraction, the batch is taken to a dryer for additional water removal. The tumbling action of the dryer also loosens and fluffs the laundered items. After drying, items of clothing are usually pressed and flat work, such as towels and linens, are ironed and folded. The laundering process can be automated so that laundry workers only load the soiled goods onto a conveyor after sorting, program the laundry cycle, and transport the cleaned goods from the dryer to stations for pressing, ironing, and folding.

The typical DOD laundry plant includes rows of washer-extractors, dryers, and presses as well as two flat work ironers. Batches are transported between the stations in the laundry plant in laundry carts, on conveyors, and on overhead rail systems. Steam is often used to supply heat to the presses and ironers and to heat water for the washers. Dryers are often direct-fired gas units, but steam and electricity are sometimes used to provide heat in dryers.

Participating Installations

Table 1 lists the installations that participated in the DOD Laundry Plant Energy Efficiency Improvement Study and the type of laundry operation at each installation.

Table 1 documents a movement by DOD installations to contract laundry operations. Cuts in funding for facilities' maintenance and personnel often make it appear easier for a facility to monitor a contract for laundry operations than to actually run the

* All figures are included at the end of their corresponding chapters.

laundry facility. The uncertainty for many base laundries was discussed by Claude Rudd, Laundry and Dry Cleaning Specialist at Fort Lee, VA, in an interview published in *Laundry News* (September 1993):

> The Army will continue to look at and study the most cost-effective method of laundering and processing goods on each individual facility. They will attempt to determine whether it is economically feasible to continue operating those facilities as they have been.

However, the Veterans Administration has conducted many cost comparisons on its laundry facilities and has shown that it is usually cheaper to maintain in-house operations than to pay for contracted service.

> 'In at least 95 percent of the cases, we win out in the cost comparisons by a pretty significant margin,' said Gerard Schroko, director of the A-76 program in the VA's Department of Operations (*Laundry News*, February 1993, p 1).

Table 1. DOD installations participating in the DOD laundry plant energy efficiency improvement study.

Installation	Type
Eglin AFB, FL †	GOGO*
Fitzsimmons AMC, CO	COCO**
Fort Bliss, TX †	GOGO
Fort Bragg, NC	COCO
Fort Campbell, KY †	GOCO***
Fort Dix, NJ †	GOCO
Fort Eustis, VA	COCO-GOGO
Fort Gordon, GA †	GOCO
Fort Hood, TX †	GOGO
Fort Huachuca, NM †	GOCO
Fort Jackson, SC †	GOCO
Fort Knox, KY †	GOCO
Fort Leavenworth, KS	GOGO
Fort Leonard Wood, MO	GOCO
Fort Lewis, WA	GOGO
Fort Ord, CA	COCO
Fort Polk, LA †	GOCO
Fort Richardson, AL	GOCO
Fort Riley, KS	GOCO
Fort Rucker, AL	GOCO
Fort Sam Houston, TX	GOGO
Fort Stewart †	GOCO
Great Lakes NTC, IL †	GOGO
Jacksonville NAS, FL †	GOGO
Orlando NTC, FL †	GOGO
Presidio of SF, CA	GOCO
Walter Reed AMC, DC †	GOCO
West Point, NY †	GOCO

* Government-owned, government operated
** Contractor-owned, contractor-operated
*** Government-owned, contractor-operated
† Site visited by researchers

Nevertheless, DOD laundry managers expressed a strong commitment to providing quality, timely service to their customers. Installation laundry personnel contacted for this study volunteered much needed data and willingly provided tours of their plants and overviews of the operations.

DOD Laundry Data

Survey data revealed some anomalies that proved it difficult to identify specific trends in utility (electricity, natural gas, oil, water, sewage) usage and cost. For example, varying utility rates directly contribute to variances in facility operating expenses. However, utility use is often not metered at the installation laundry. Instead, the utility consumption and bills were estimated from formulas several years old that no longer accurately reflect current utility consumption due to changes in equipment efficiency, operational procedures, base-wide utility use, and annual production.

Figure 2 shows the total energy consumption (MBtu/yr) for 15 installations by total production (pieces per year). Figure 3 shows the total energy cost ($/yr) for these installations, again arranged by total production. Figure 4 (electric energy), Figure 5 (nonelectric energy), and Figure 6 (total energy) show the expected general trend of energy consumption increasing as production increases. Nonelectric energy consumption is the sum of natural gas, oil, and steam consumption for each facility. Figures 2, 5, and 6 show that nonelectric energy consumption is much more significant (from 88.0 to 98.4 percent) than electricity consumption in DOD laundries. The variability of the data demonstrates the need for precise metering and recording of energy consumption at DOD facilities.

Figure 7 (electric energy), Figure 8 (nonelectric energy), and Figure 9 (total energy) show normalized energy consumption on a per-pound basis plotted against annual production. The scatter in the energy consumption data on these three plots indicates varying rates of energy consumption, normalized per pound of laundry processed, among similarly sized laundry facilities. These survey results reinforce the need for improvements in energy consumption monitoring and equipment modernization efforts in DOD facilities. Note that the increase in energy consumption per pound of laundry processed for small facilities is not unexpected due to the effect of economies of scale. Additionally, the scattered data makes it difficult to develop a reliable model for predicting laundry facility energy consumption.

Figure 10 (electric energy cost), Figure 11 (nonelectric energy cost), and Figure 12 (total energy cost) show a significant degree of variability in the cost of utilities for similarly sized facilities throughout DOD, attributable to differences in equipment,

energy consumption monitoring, and local utility rates. Electric energy costs ranged from 7.7 to 38.4 percent of total energy expenditures in DOD laundries. Figure 13 shows the general trend of annual water consumption increasing with annual production for the DOD facilities. Normalized water consumption (Figure 14) shows that DOD laundry facilities use approximately 5 gal of water per pound of laundry processed regardless of annual production. Figure 15 reveals the effect of varied utility rates on annual water cost. Some of the facilities' utility costs are based on metered billing while others' are billed as a percentage of total consumption for the entire installation. Sewage production (in gallons) is approximately 20 percent lower than water consumption. This is largely due to water loss during drying and from steam leaks.

The number of laundry personnel per million pounds of laundry processed for the DOD facilities (Figure 16) indicates that smaller plants may require more operators than large plants. The need for more employees in smaller plants may be due to the fact that larger facilities are able to employ labor-saving technologies, such as continuous batch washers, that the smaller plants cannot support. Efforts to implement meters and accurately monitor utility consumption in DOD facilities could result in energy savings (and cost reductions) by revealing inefficient processes that cannot be identified without utility consumption data. Appendix B (Tables B3 and B4) give the data plotted in Figures 2 through 16 in spreadsheet form.

Commercial Laundry Data

Results from a late 1992 survey of commercial facilities were furnished by the Uniform and Textile Service Association.* The consistent nature of the commercial laundry data indicates acquisition of the data via a more precise system of utility consumption monitoring than exists in the DOD due to the fact that the commercial laundry facilities must operate economically and remain competitive in the marketplace. Though annual utility costs were not included in the commercial laundry data set, it is obvious that the commercial facilities must pay similar rates to DOD facilities for their utilities, with rates varying with location. Figures 17 through 20 show commercial laundry data for normalized consumption of electricity, nonelectric energy, total energy, and water. Figure 21 gives the number of laundry personnel per million pounds of laundry processed for the commercial facilities. The next section compares the commercial and DOD laundry data.

* (Formerly [1993] the Institute of Industrial Launderers), 1730 M St. NW., Suite 610, Washington, DC 20036, tel. 202/296-6744.

Comparison of Commercial and DOD Laundry Data

The surveys of 22 commercial laundries and 21 military laundries yielded data that included annual energy consumption, annual water consumption, and number of plant personnel. Survey results for the military facilities were obtained by USACERL. These data are for the entire physical plant of the laundry facilities and therefore include energy used for building lighting, domestic water heating, heating, and cooling. A search for facilities having data limited specifically to equipment was unsuccessful. Rarely, if ever, is any of the equipment individually metered. Appendix C summarizes the efforts undertaken to acquire commercial facility data and includes a copy of the commercial laundry survey form.

Data from the commercial laundry surveys were entered into a spreadsheet for analysis. Electricity use, nonelectric energy use, water use, and the number of personnel employed were examined as a function of production. Resource use was normalized on the basis of the amount of laundry processed (per pound). Appendix B (Tables B1 and B2) include the spreadsheet data and computational results. For each quantity analyzed, the scatter in normalized use is too great to show any significant trend with production rate. Commercial and military facility resource use were compared based on average values. The military facilities with the two lowest production rates (facilities P and Q) as well as military facility D, with a production rate near the low end of the range, all show much higher consumption than the remaining military facilities. A similar result applies to the commercial facility with the lowest production rate, facility DGA. In the sections that follow, graphs of the results for all the facilities are presented, followed by graphs of results for all facilities except the "high value" facilities discussed above (P, Q, D, and DGA). The elimination of the high value data allows the use of an expanded scale for the ordinate of the graph, thereby providing better resolution to the plotted results.

Electricity Use

Figure 22 shows the reported electricity use. The weighted average of the electricity use of the military facilities is 0.137 kWh/lb, 11 percent higher than the 0.123 kWh/lb for the commercial facilities. The electricity consumption is below 0.4 kWh/lb of goods laundered for all but three facilities, military facilities P and D, and commercial facility DGA. Figure 23 shows the electricity use of all facilities with electricity use rates below 0.4 kWh/lb. The weighted average of the electricity use of these military facilities is 0.105 kWh/lb, 12 percent lower than the 0.119 kWh/lb for the commercial facilities.

Nonelectric Energy Use

The nonelectric energy is the sum of the energy content in natural gas (1000 Btu/scf), oil (145,000 Btu/gal) and steam (1000 Btu/lb). Steam use is not reported for the commercial facilities. However, it seems unlikely that any of the commercial facilities would purchase steam from an external source. Rather, they would generate their required steam internally from purchased natural gas- or oil-fired boilers, so that any steam energy use would be included in the reported fuel use. Five military facilities report purchased steam use in addition to natural gas and/or fuel oil. Only one commercial facility reports any oil use as opposed to five military facilities.

Figure 24 shows the reported nonelectric energy use. The weighted average of the nonelectricity energy use of the military facilities is 8.67 kBtu/lb, 160 percent higher than the 3.34 kBtu/lb for the commercial facilities. The nonelectric energy consumption is below 20,000 Btu/lb for all but two facilities, military facilities P and D. Figure 25 shows the nonelectric energy use of all facilities with use rates below 20 kBtu/lb, except commercial facility DGA. Commercial facility DGA is excluded from the results so that the same facilities are represented as in the other "expanded scale" graphs. The weighted average of the nonelectric energy use of these military facilities is 7.48 kBtu/lb, 129 percent higher than the 3.27 kBtu/lb for the commercial facilities.

Total Energy Consumption

The total energy is the sum of the energy content in natural gas (1000 Btu/scf), oil (145,000 Btu/gal), steam (1000 Btu/lb), and Electricity (3413 Btu/kWh). Figure 26 shows the total energy use. The weighted average of the total energy use of the military facilities is 9.14 kBtu/lb, 143 percent higher than the 3.76 kBtu/lb for the commercial facilities. The total energy consumption is below 25,000 Btu/lb for all but two facilities, military facilities P and D. Figure 27 shows the total energy use of all facilities with use rates below 25 kBtu/lb, except commercial facility DGA, which is excluded from the results so that the same facilities are represented as in the other "expanded scale" graphs. The weighted average of the total energy use of these military facilities is 7.84 kBtu/lb, 114 percent higher than the 3.67 kBtu/lb for the commercial facilities.

Water Use

Figure 28 shows the reported water use. The weighted average of the water use of the military facilities is 5.35 gal/lb, 101 percent higher than the 2.66 gal/lb for the commercial facilities. The water consumption is below 10 gal/lb for all but two facilities (military facility D and commercial facility DGA). Water consumption data

for military facility P was not available. Figure 29 shows the water use of all facilities with use rates below 10 gal/lb. The weighted average of the water use of these military facilities is 3.62 gal/lb, 40 percent higher than the 2.58 gal/lb for the commercial facilities.

Comparison With Other Data

The results of surveys of "four large chain companies" were reported in *Textile Rental* (June 1992, pp 28-32). Appendix D includes a copy of this and other articles of interest. The results were aggregated by region into "north" and "south," so as not to reveal the identity of the individual companies or facilities. A comparison of results from 1991 with those from 1984 showed "a significant reduction in natural gas/fuel oil use and water consumption" and that "use of electricity has increased slightly."

Figure 30 shows the average electricity consumption results of the *Textile Rental* surveys and the surveys analyzed in this study. The averages of all facilities analyzed here are labeled "All" and the expanded-scale averages, excluding the "high value" results from the commercial and military data, are labeled "Reduced Set." Similarly, Figure 31 shows the average nonelectricity consumption results of the *Textile Rental* surveys and the surveys analyzed here; Figure 32 gives the average total energy consumption results. Figure 33 shows the average water consumption results. The weighted average electricity consumption of the commercial and military facilities analyzed here are higher than the average electricity consumption reported for 1991 in the *Textile Rental* article. The weighted average nonelectric energy consumption of the commercial facilities analyzed here ranges from 3.27 kBtu/lb to 3.34 kBtu/lb, which falls within the range of the average fuel consumption reported in the *Textile Rental* article (3.06 kBtu/lb to 4.54 kBtu/lb). The weighted average nonelectric energy consumption of the military facilities analyzed here ranges from 7.48 kBtu/lb to 8.67 kBtu/lb, more than double the nonelectric energy consumption of the other groups shown. Similarly, the weighted average total energy consumption of the military facilities analyzed here ranges from 7.84 kBtu/lb to 9.14 kBtu/lb, more than double the total energy consumption of the other groups shown in recent years. The weighted average water consumption for the commercial facilities analyzed here is within the range of the average water consumption reported in the *Textile Rental* article, while that of the reduced set of military facilities is higher by a factor of about 1.5.

Personnel

Figure 34 shows the reported number of personnel. The weighted average of the number of personnel for the military facilities is 13.97 per million pounds, 76 percent higher than the 7.94 per million pounds for the commercial facilities. The number of

personnel is below 40 per million pounds of goods laundered for all but three facilities, military facilities P and Q, and commercial facility DGA. Figure 35 shows the number of personnel of all facilities with personnel rates below 40 per million pounds. The weighted average of the personnel use of these military facilities is 12.70 per million pounds, 65 percent higher than the 7.71 per million pounds for the commercial facilities.

Summary

To summarize, the total energy consumption of the commercial facilities considered is significantly lower than that of the military facilities studied. The nonelectric energy consumption of the military facilities is much greater than that of the commercial facilities, while the electric energy consumption of the military facilities is slightly lower than that of the commercial facilities. This result is not surprising, since the commercial facilities use more advanced technologies. The implementation of advanced technologies and electronic control mechanisms can significantly reduce consumption of nonelectric energy, but requires slightly more electricity to operate. Automated systems also require fewer operators. In this instance, increasing electricity consumption by a small percentage yields a significant payback via conservation of other energy sources, water, and labor. Military facilities can become more cost-effective in their operation and duplicate the performance of commercial facilities by implementing advanced technologies.

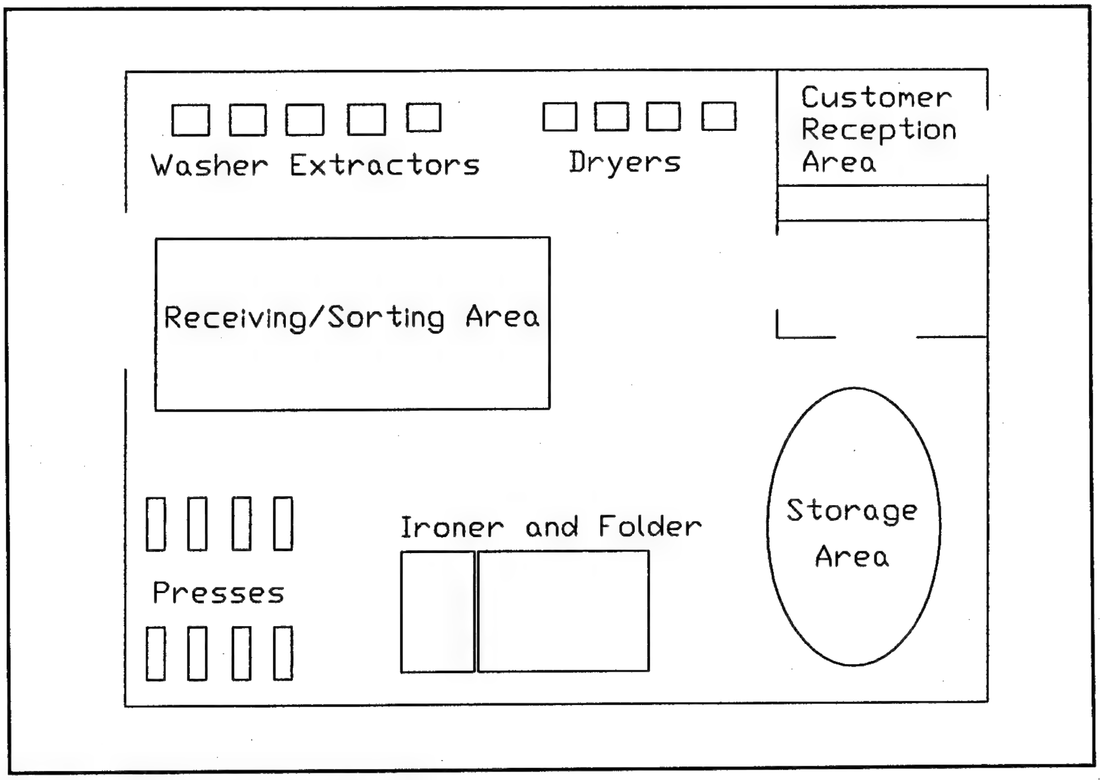


Figure 1. Typical laundry plant layout.

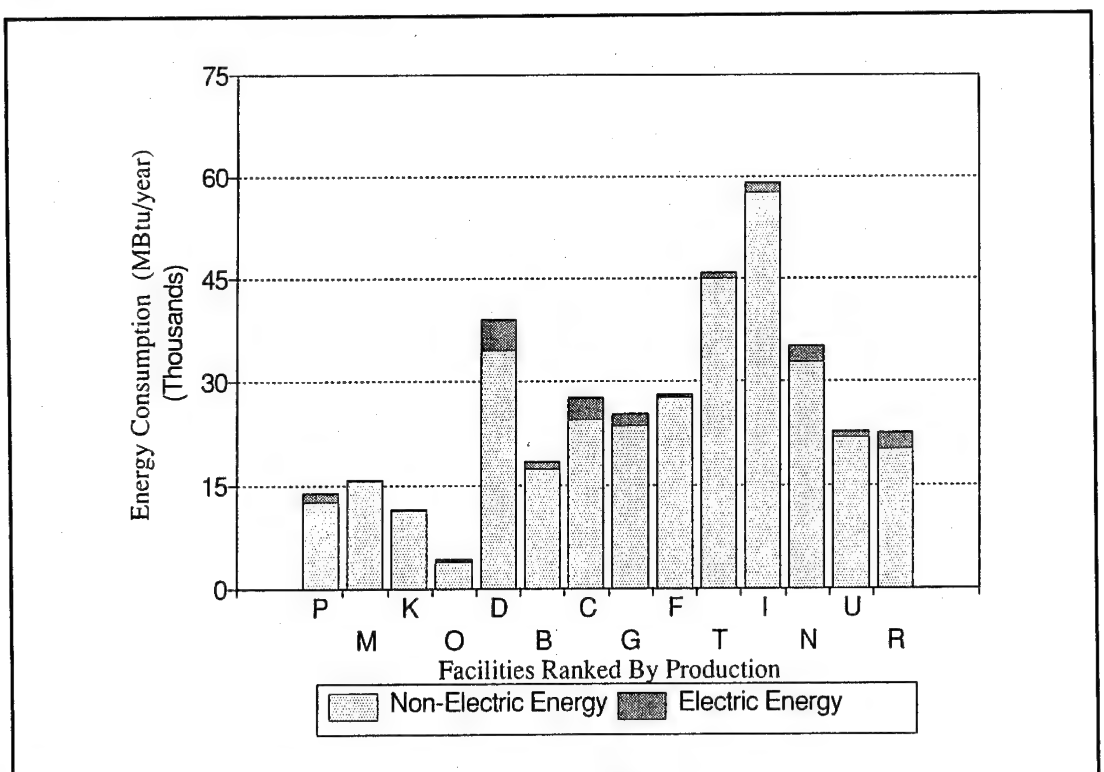


Figure 2. DOD laundry facility annual energy consumption.

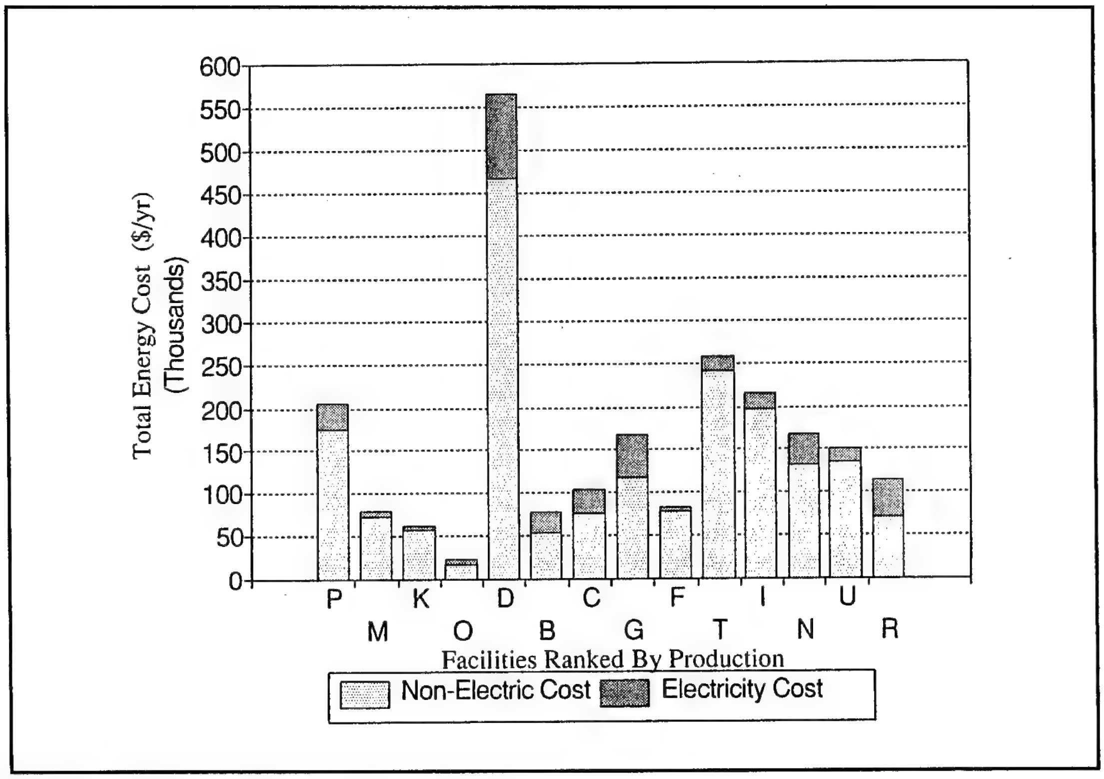


Figure 3. DOD laundry facility annual energy cost.

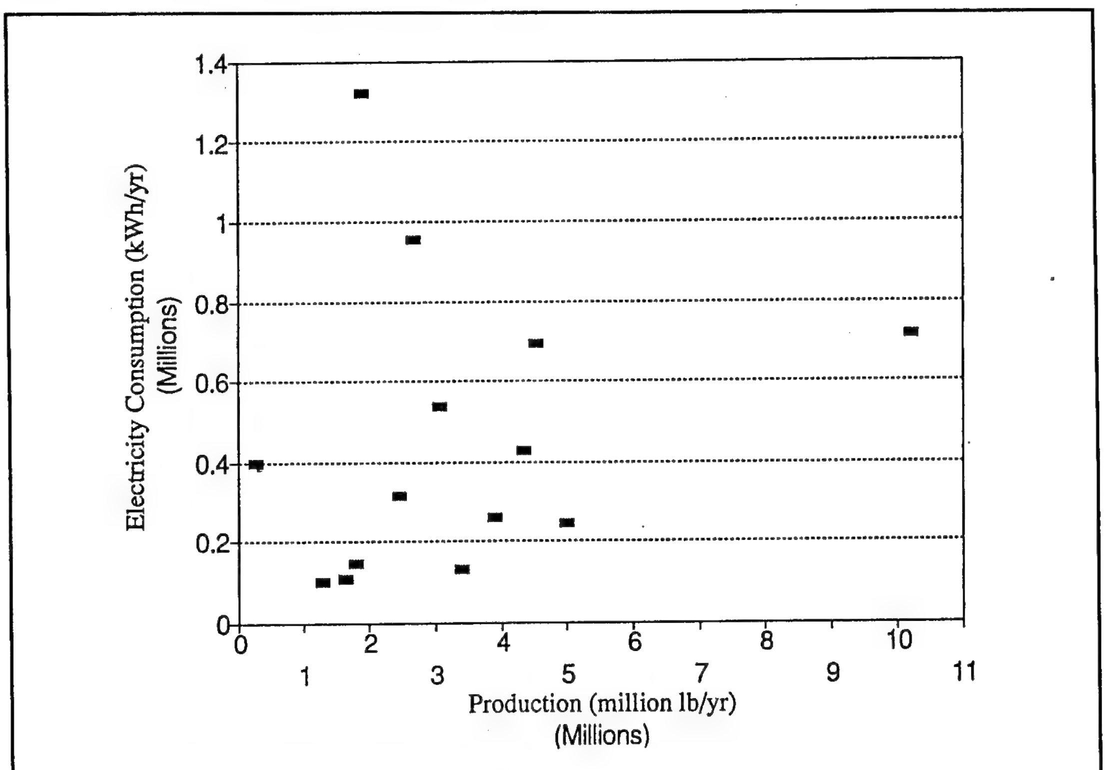


Figure 4. DOD laundry facility electricity consumption (kWh/yr).

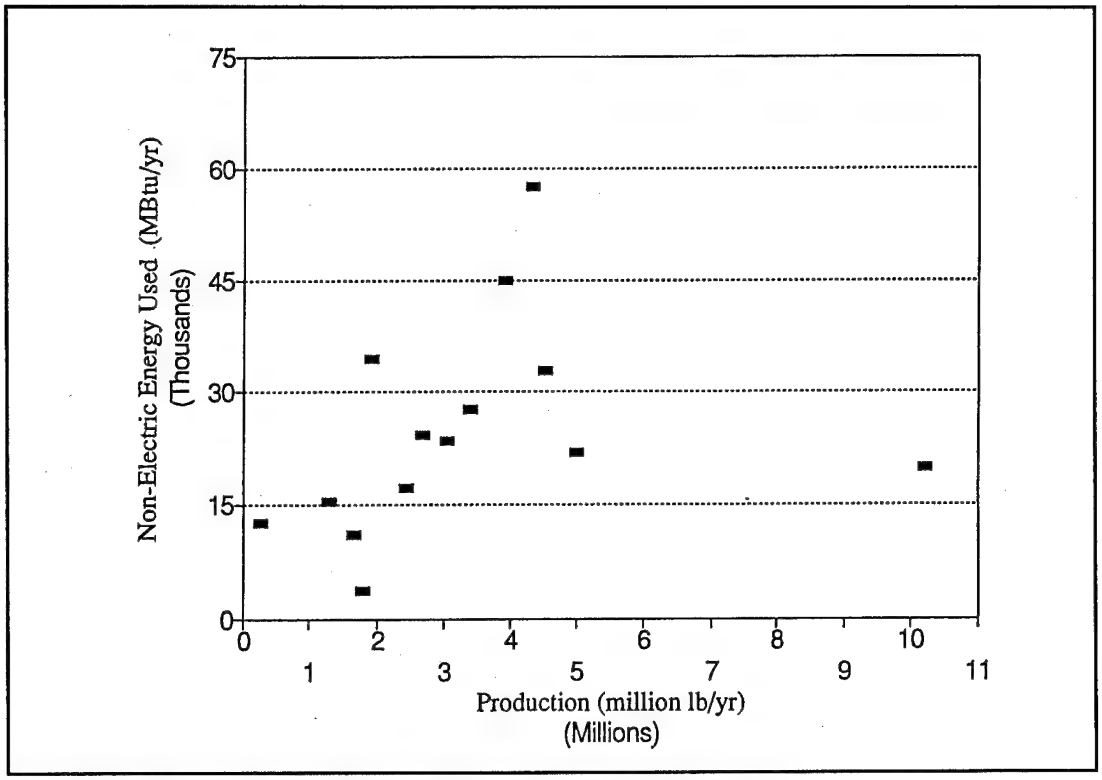


Figure 5. DOD laundry facility nonelectric energy consumption (MBtu/yr).

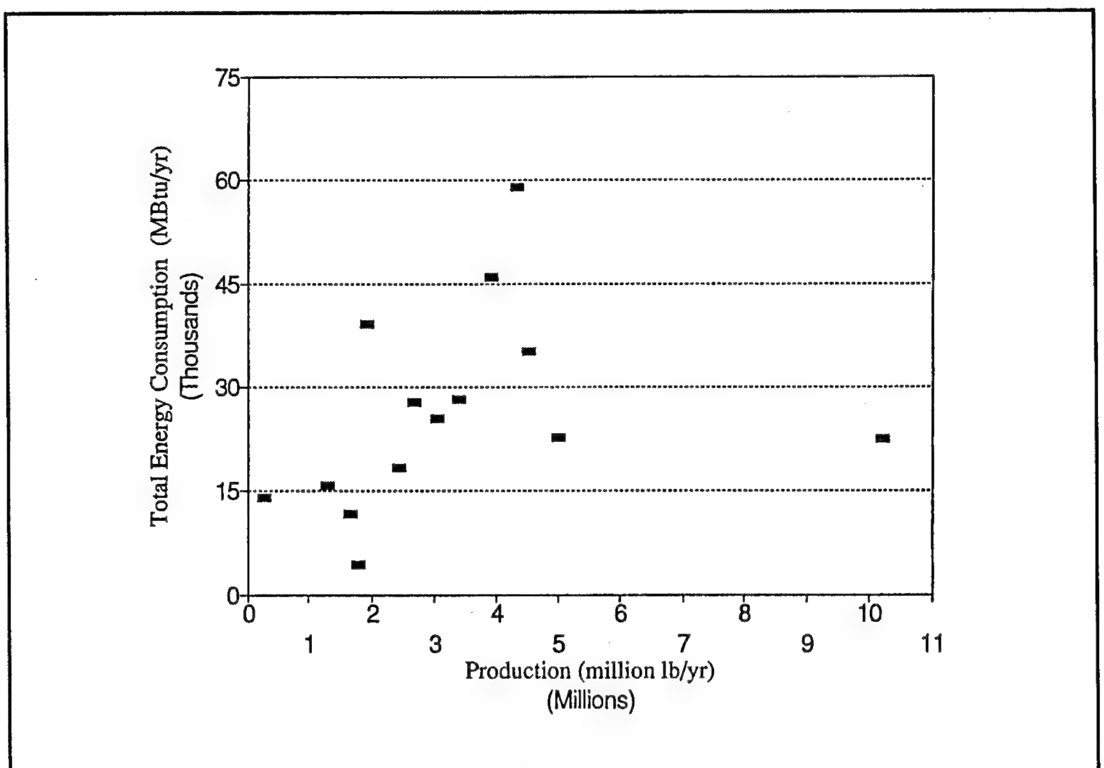


Figure 6. DOD laundry facility total energy consumption (MBtu/yr).

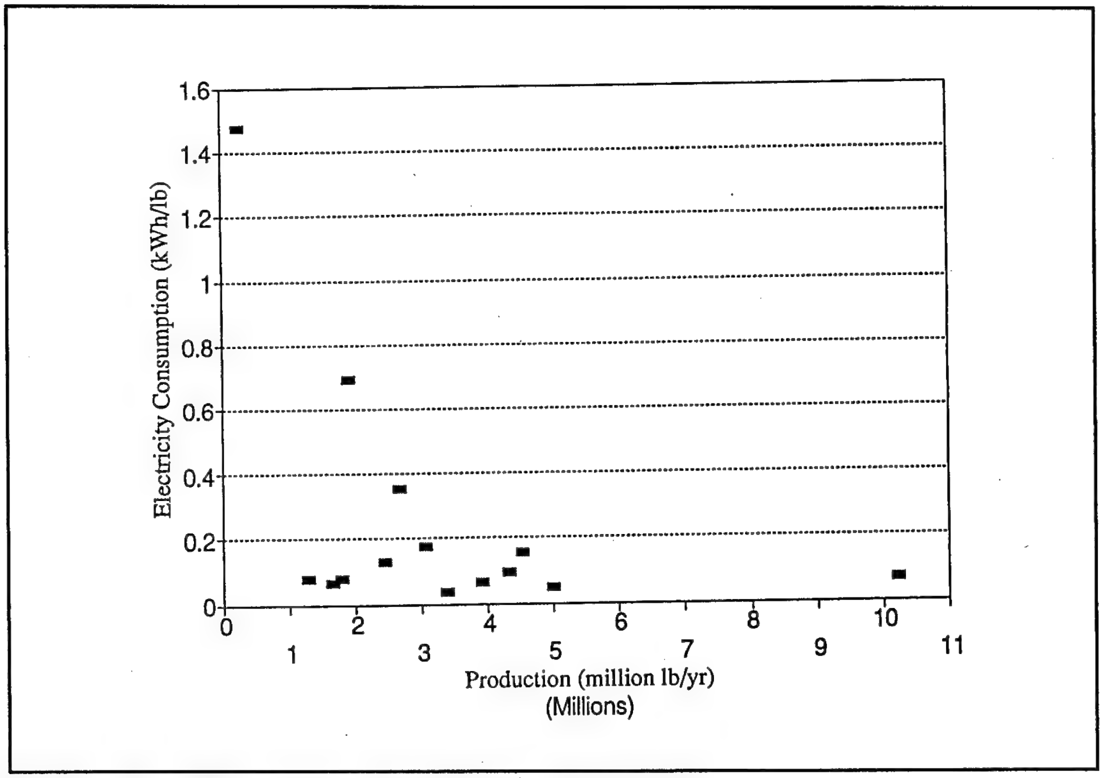


Figure 7. DOD laundry facility electricity consumption (kWh/lb).

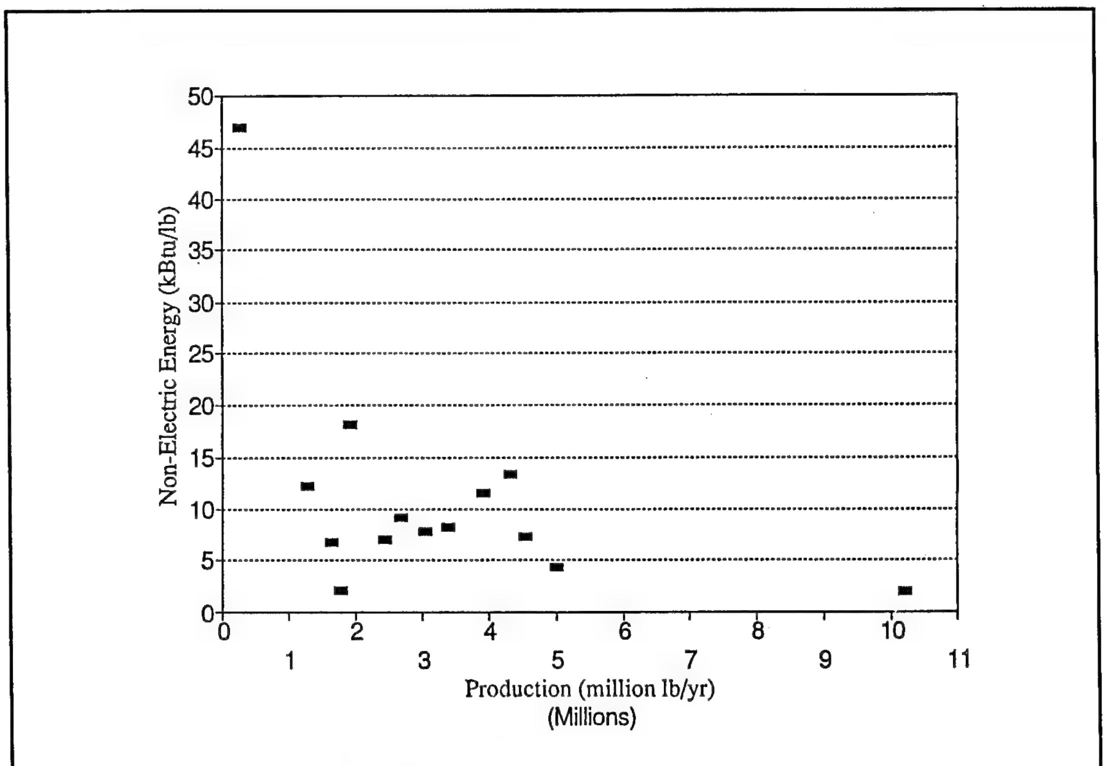


Figure 8. DOD laundry facility nonelectric energy consumption (kBtu/lb).

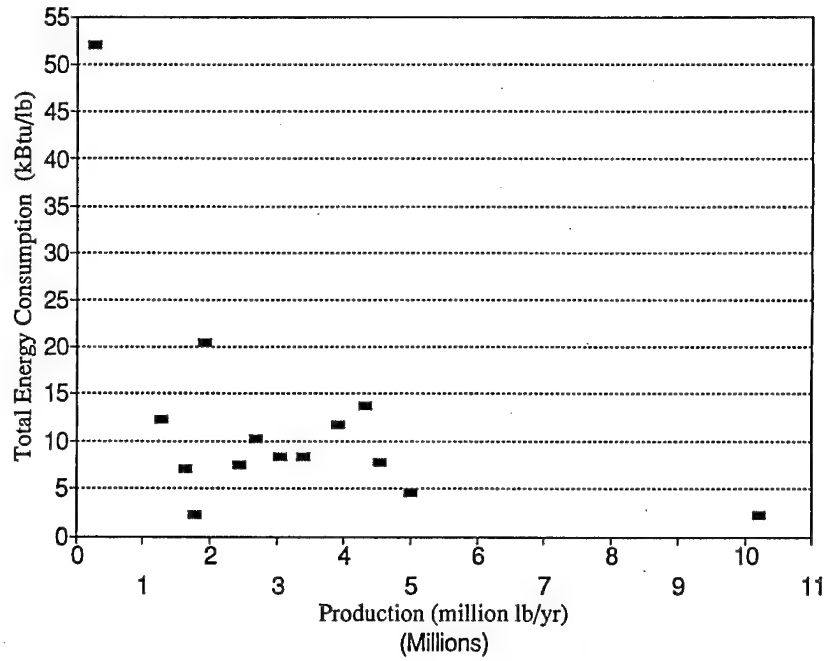


Figure 9. DOD laundry facility total energy consumption (kBtu/lb).

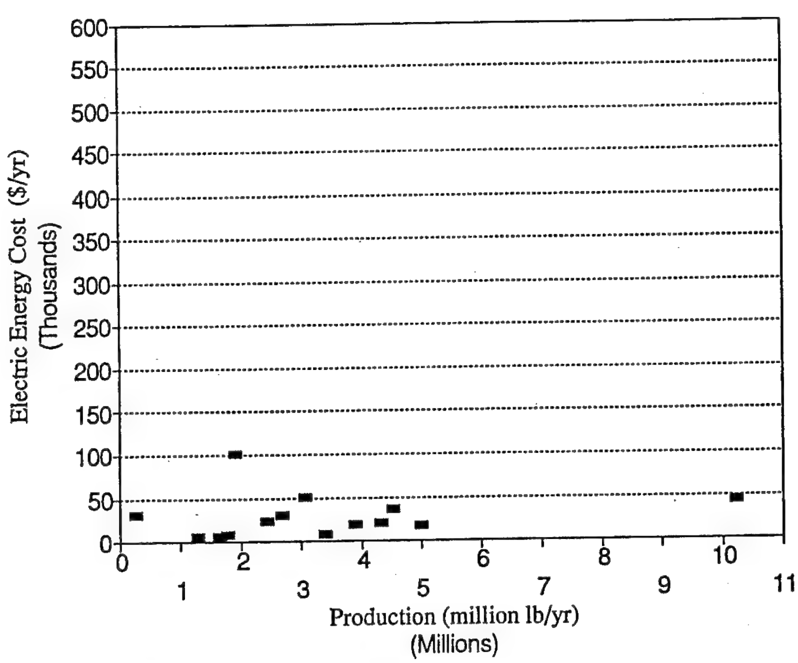


Figure 10. DOD laundry facility electricity cost ($/yr).

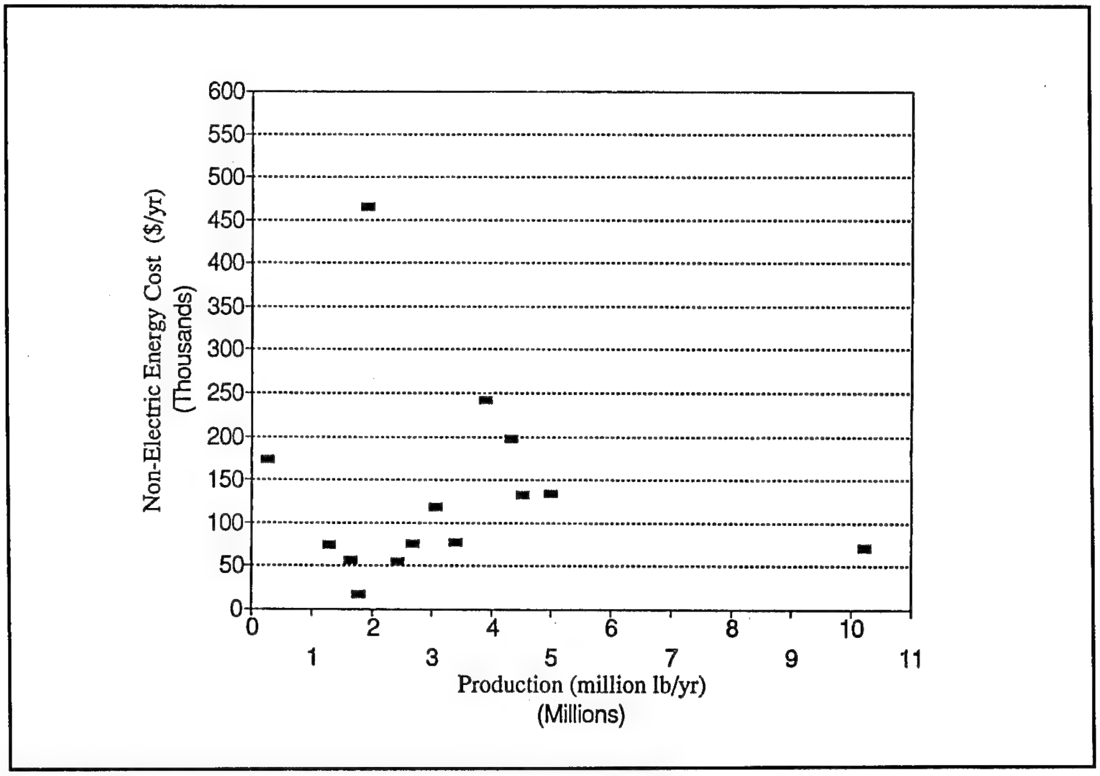


Figure 11. DOD laundry facility nonelectric energy cost ($/yr).

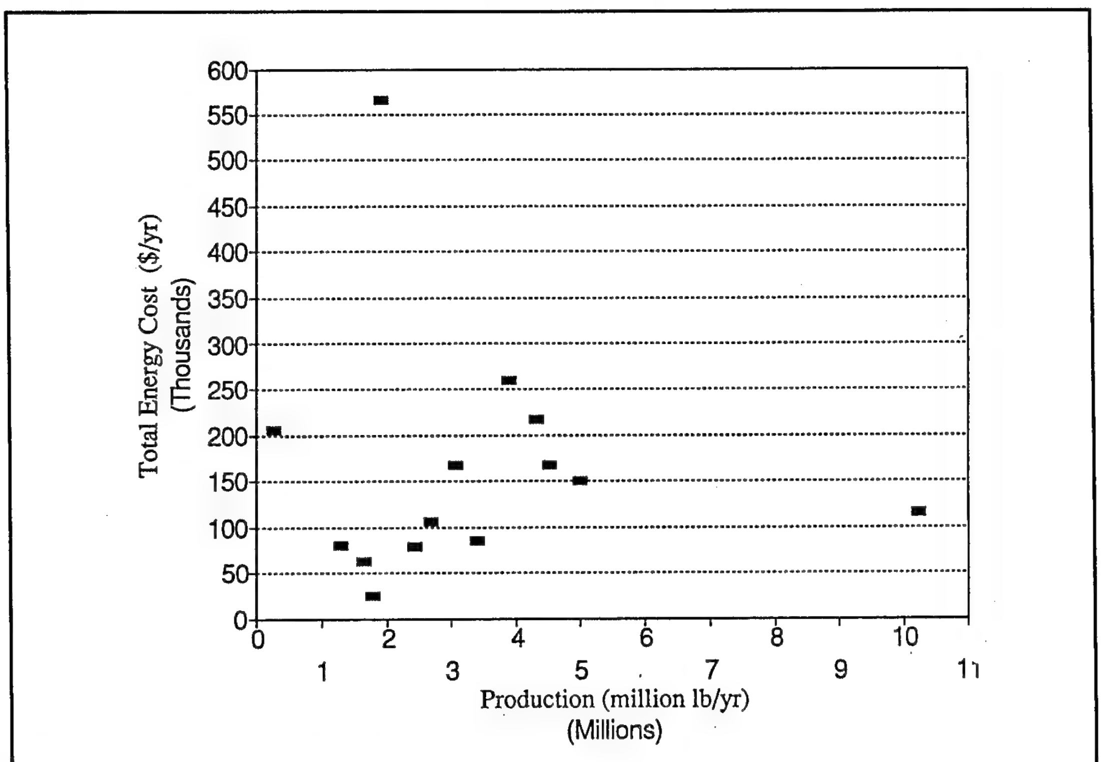


Figure 12. DOD laundry facility total energy cost ($/yr).

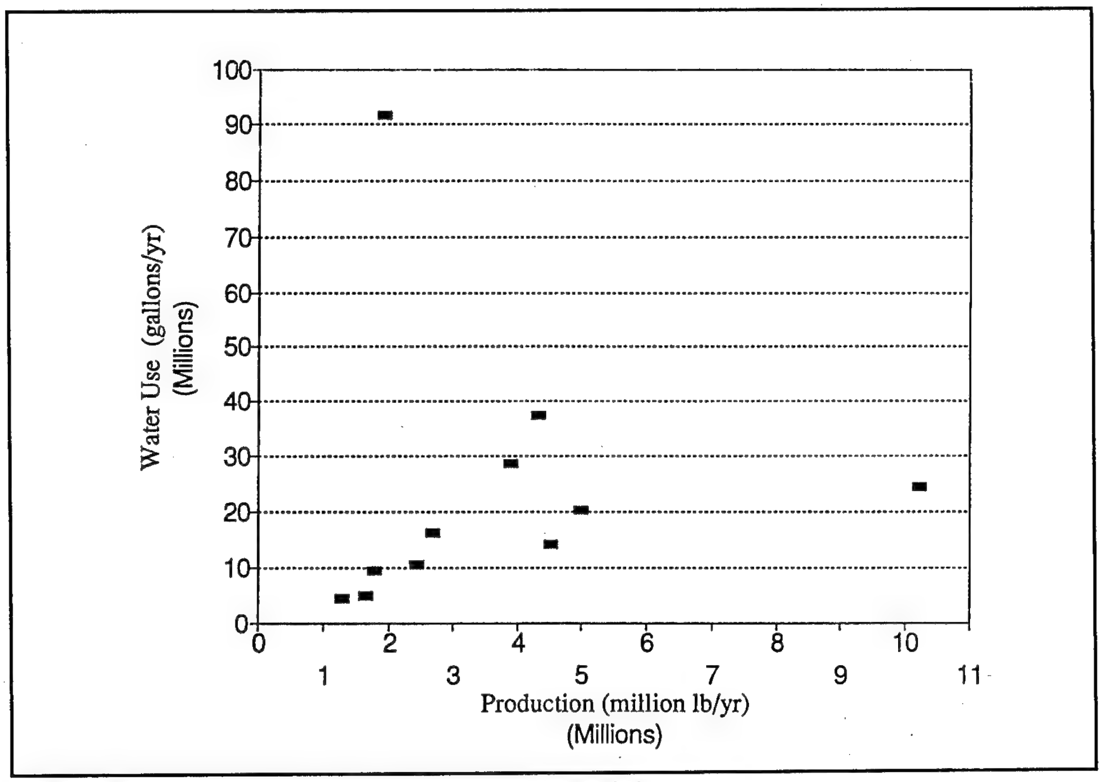


Figure 13. DOD laundry facility water consumption (gal/yr).

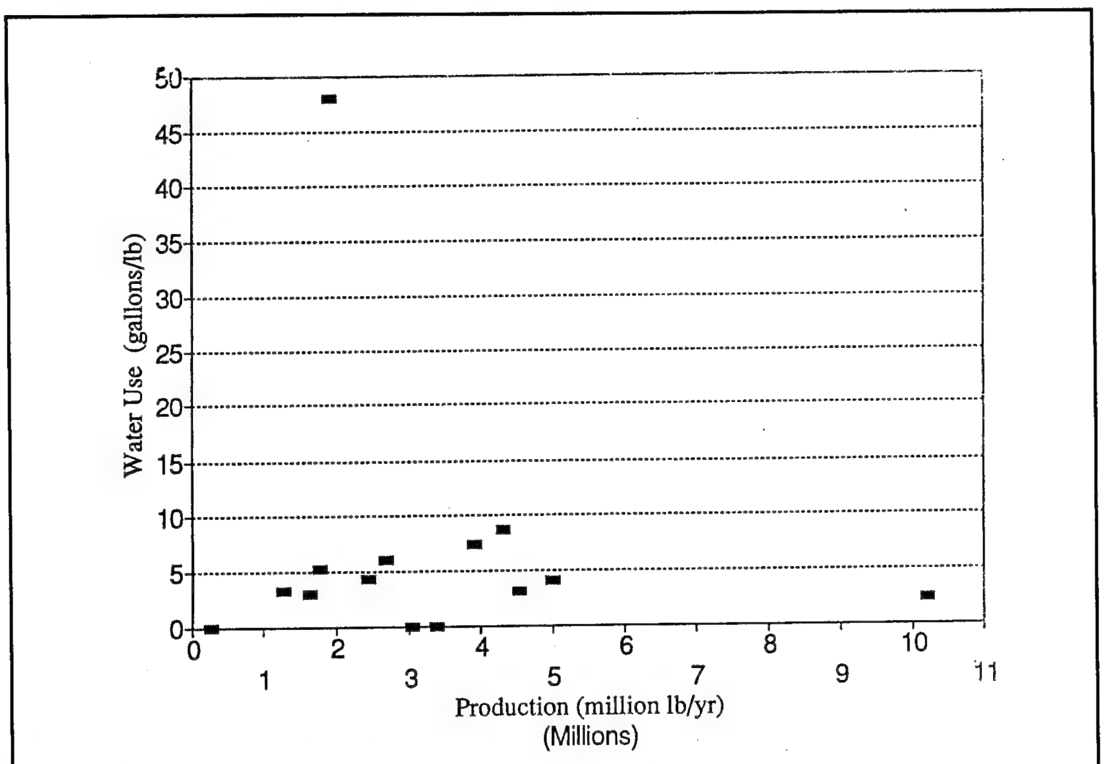


Figure 14. DOD laundry facility water consumption (gal/lb).

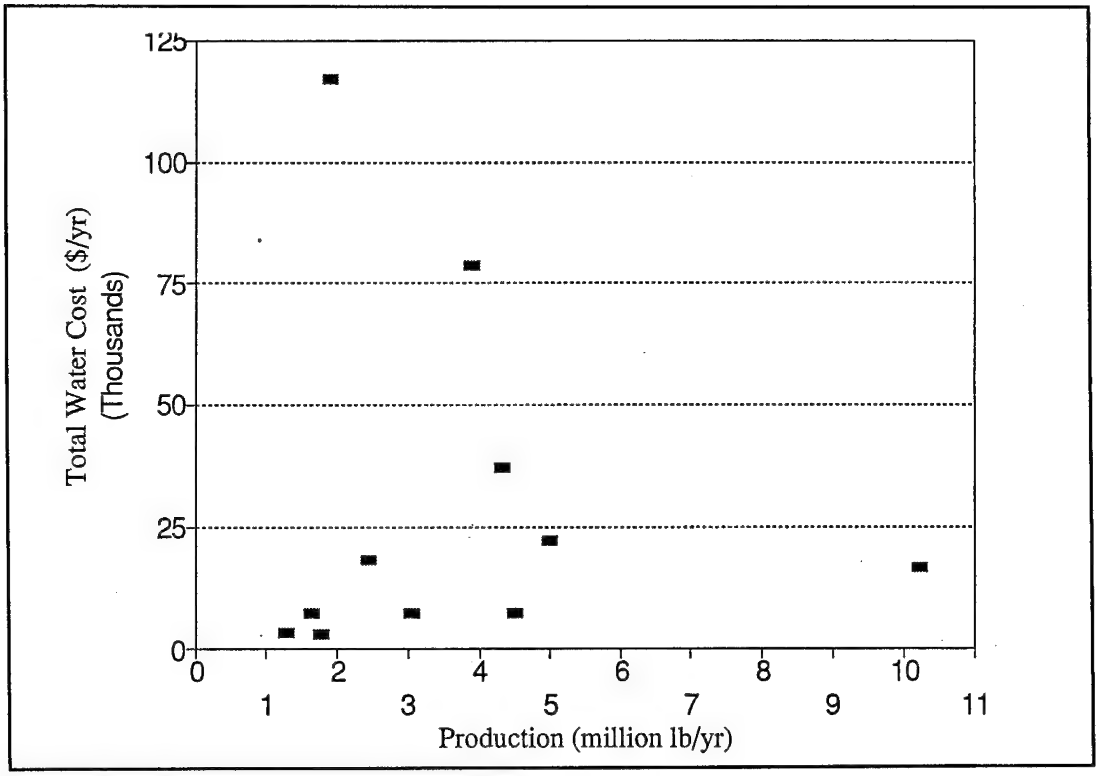


Figure 15. DOD laundry facility water cost ($/yr).

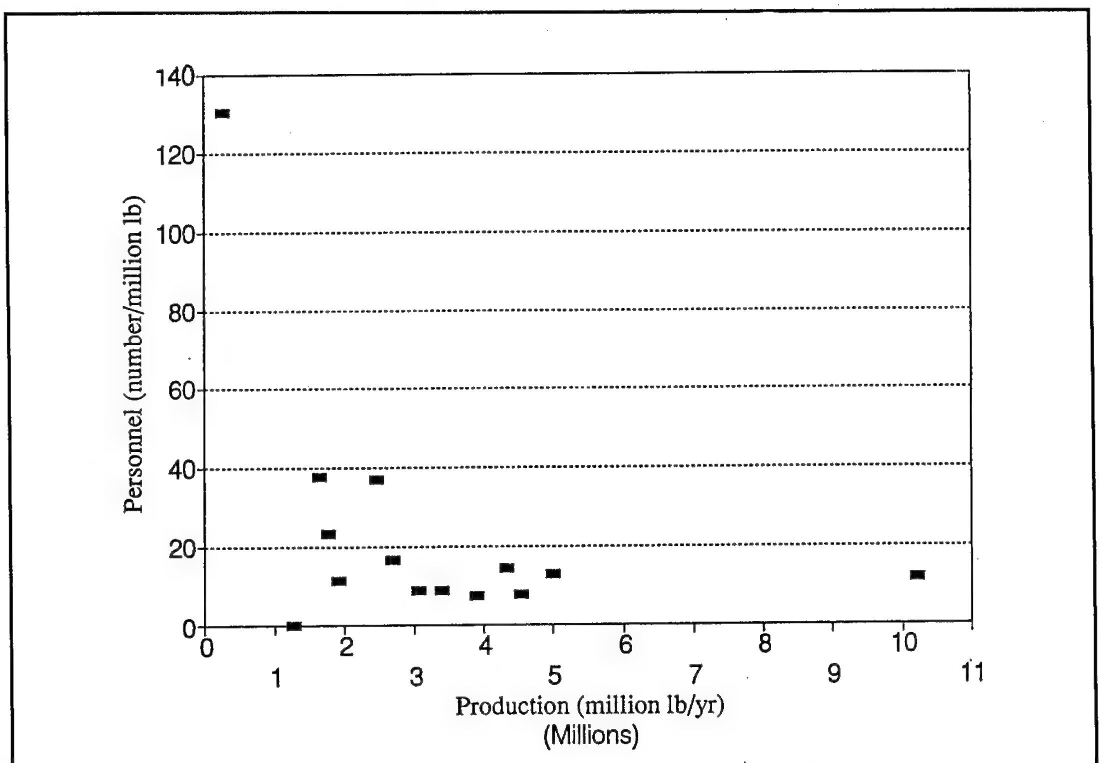


Figure 16. DOD laundry facility personnel (number/million lb processed).

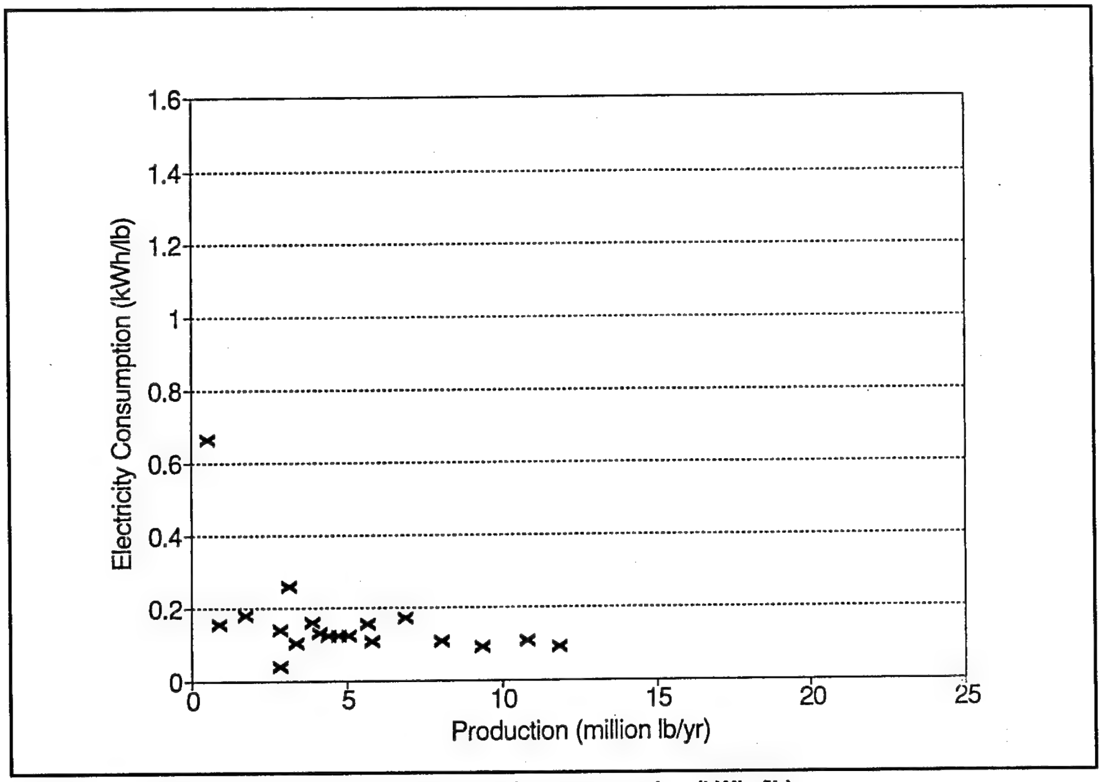


Figure 17. Commercial laundry facility electricity consumption (kWhr/lb).

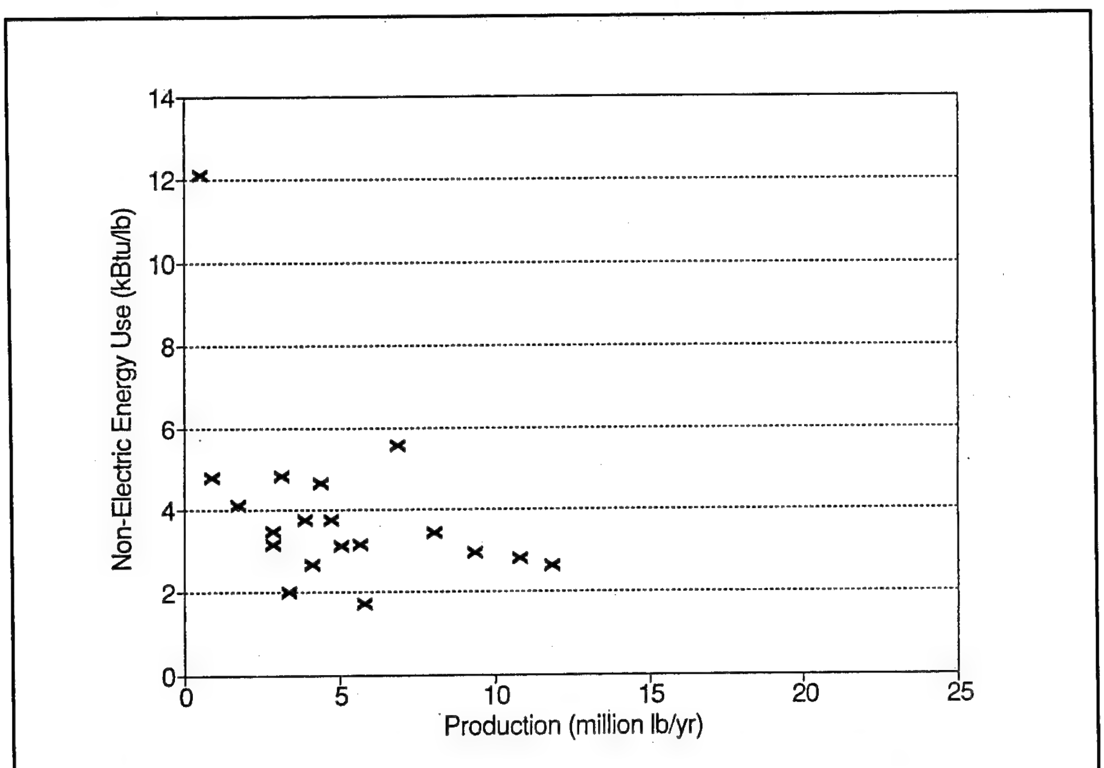


Figure 18. Commercial laundry facility nonelectric energy consumption (kBtu/lb).

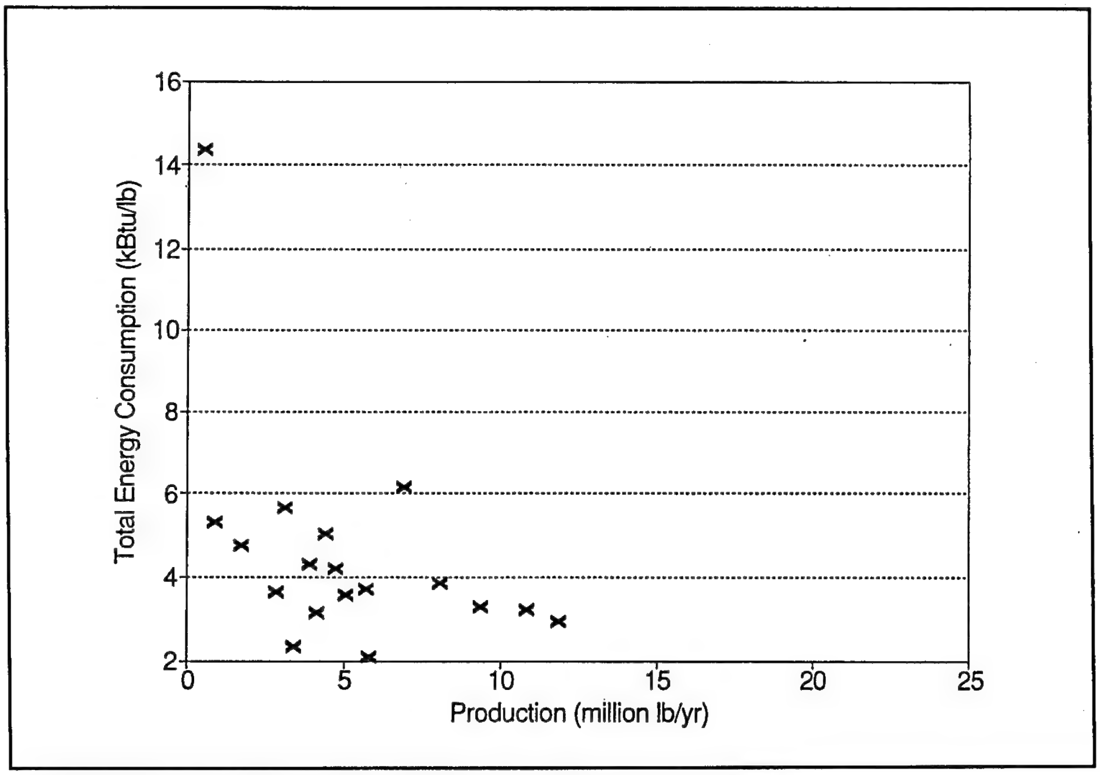


Figure 19. Commercial laundry facility total energy consumption (kBtu/lb).

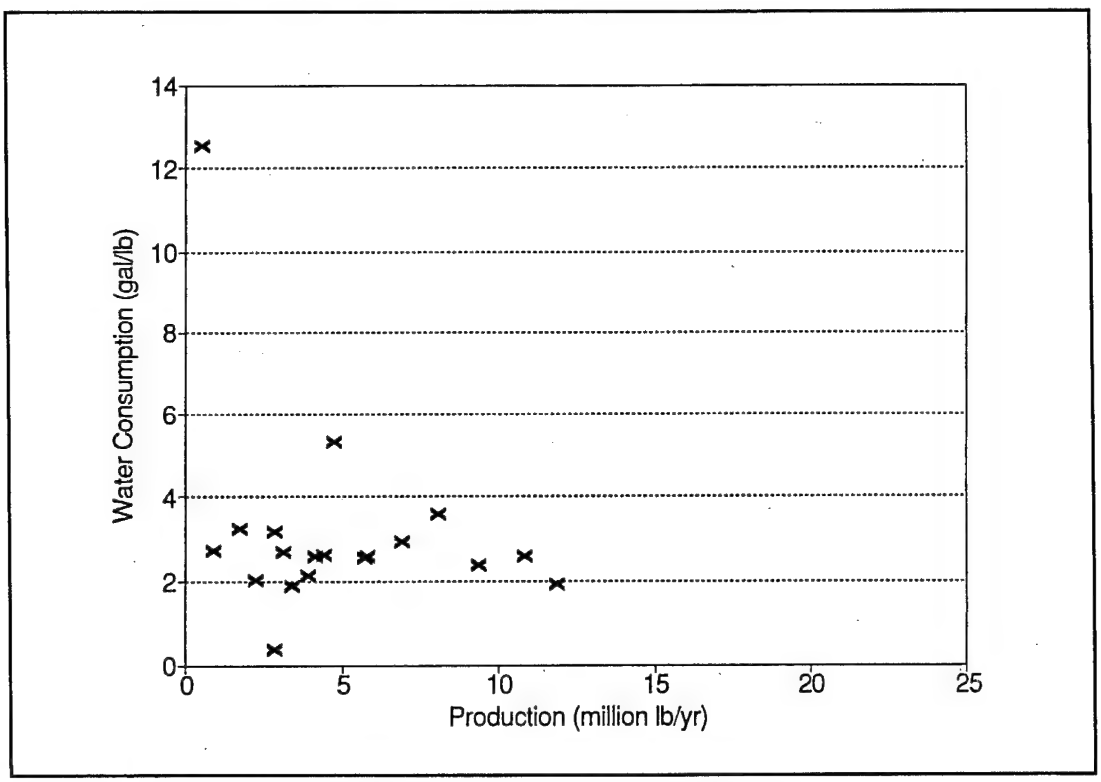


Figure 20. Commercial laundry facility total water consumption (gal/lb).

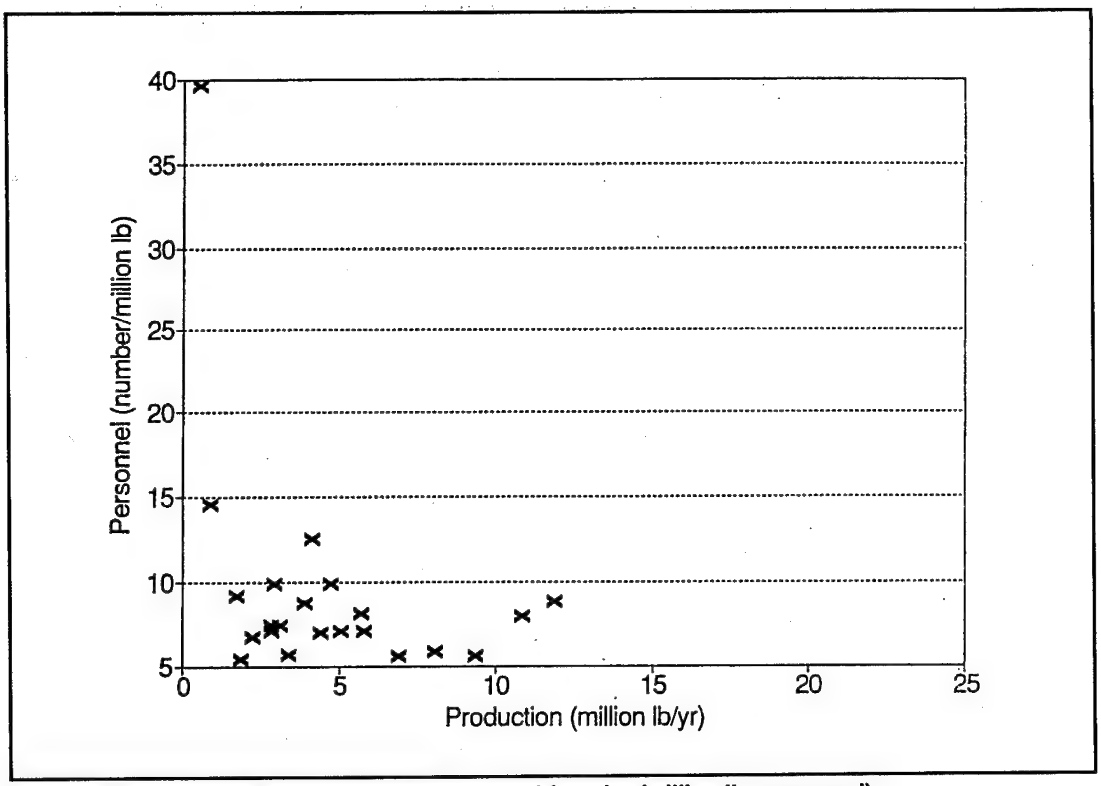


Figure 21. Commercial laundry facility personnel (number/million lb processed).

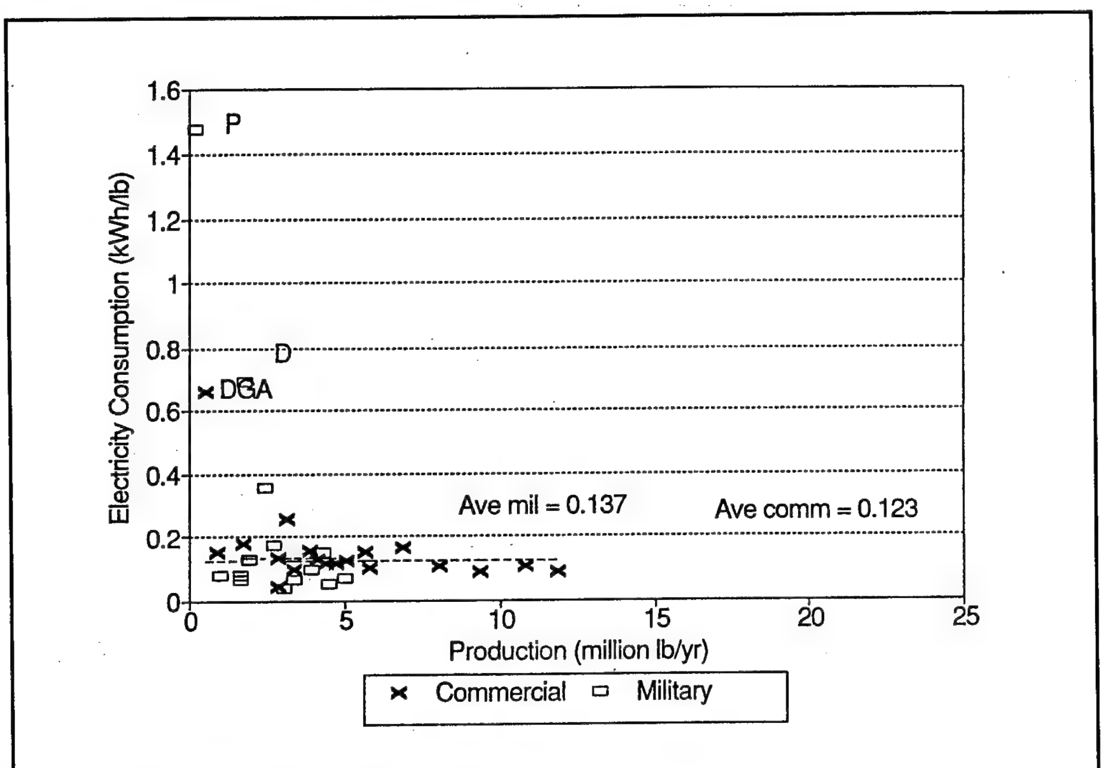


Figure 22. Electricity consumption comparison.

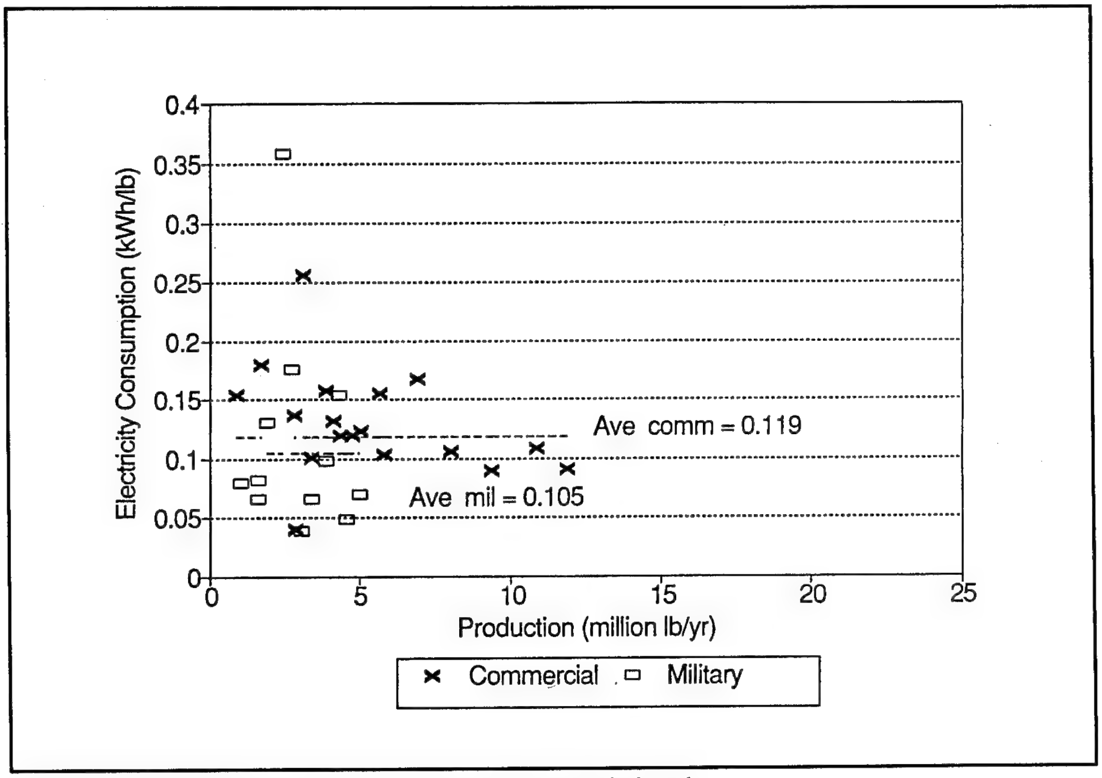


Figure 23. Electricity consumption comparison, expanded scale.

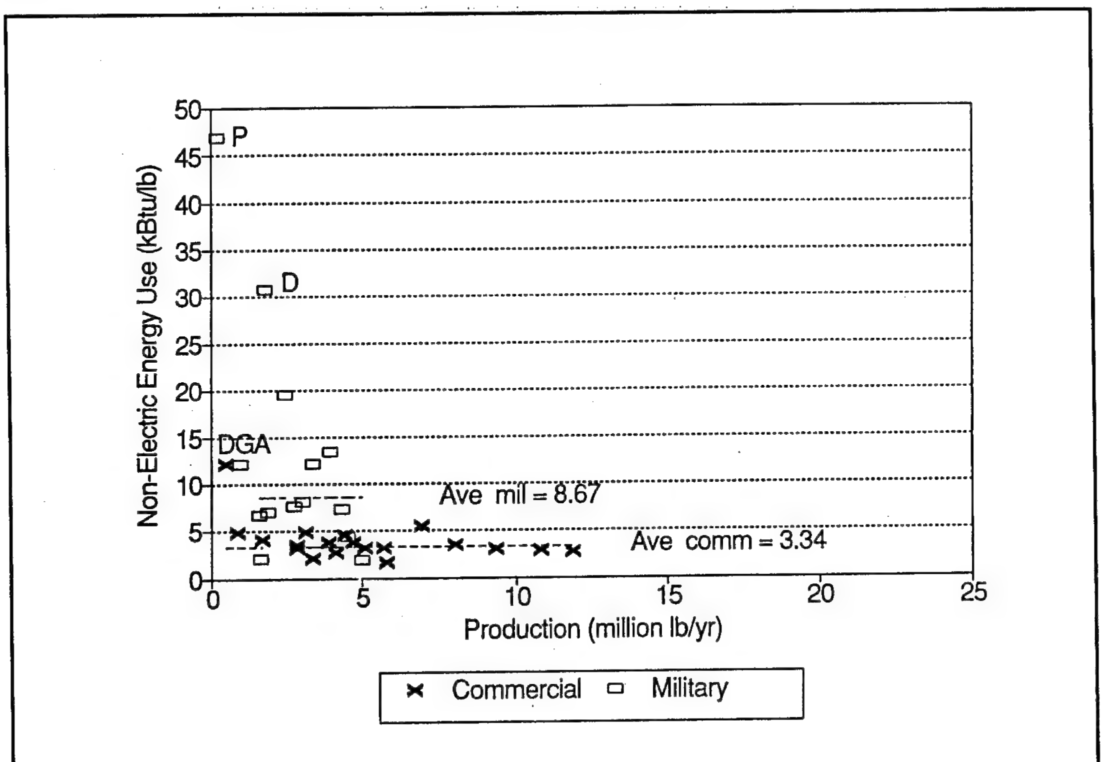


Figure 24. Nonelectric energy consumption comparison.

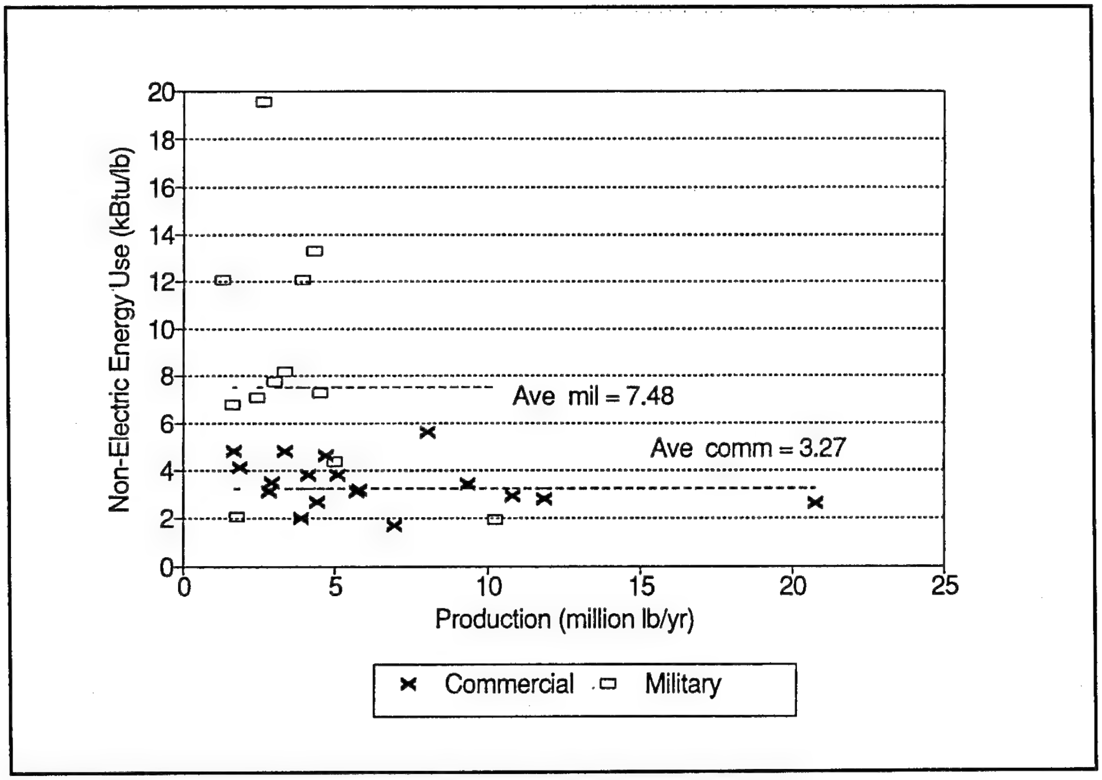


Figure 25. Nonelectric energy consumption comparison, expanded scale.

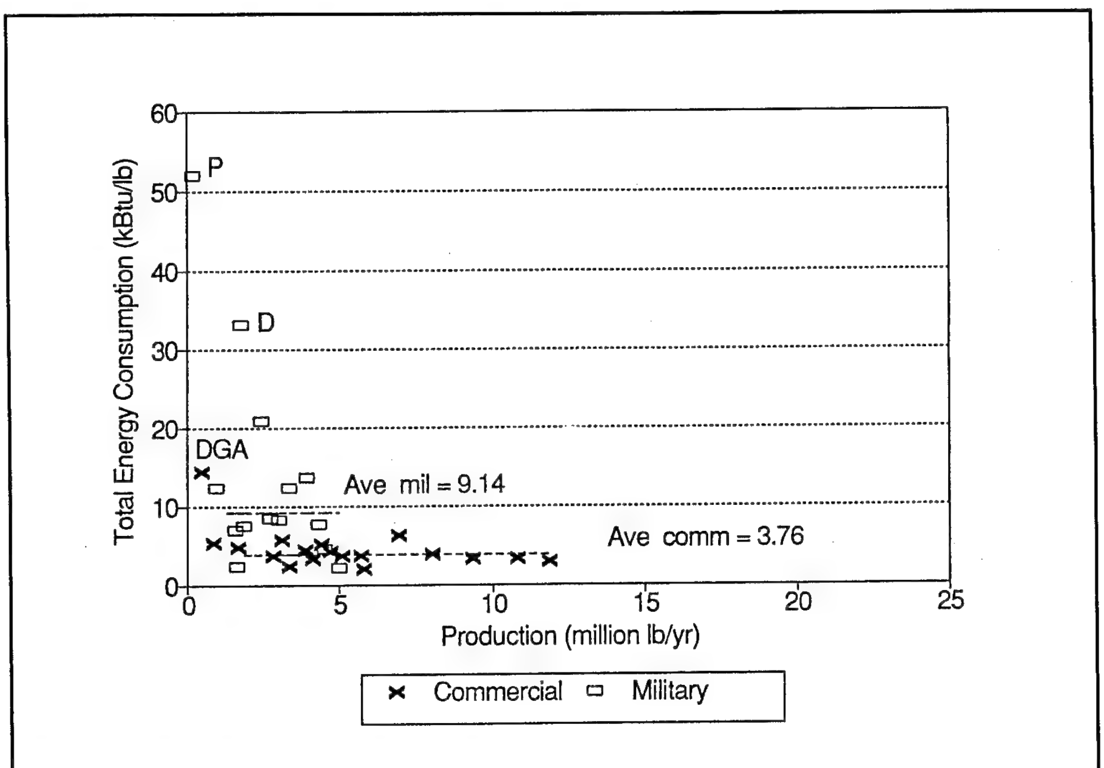


Figure 26. Total energy consumption comparison.

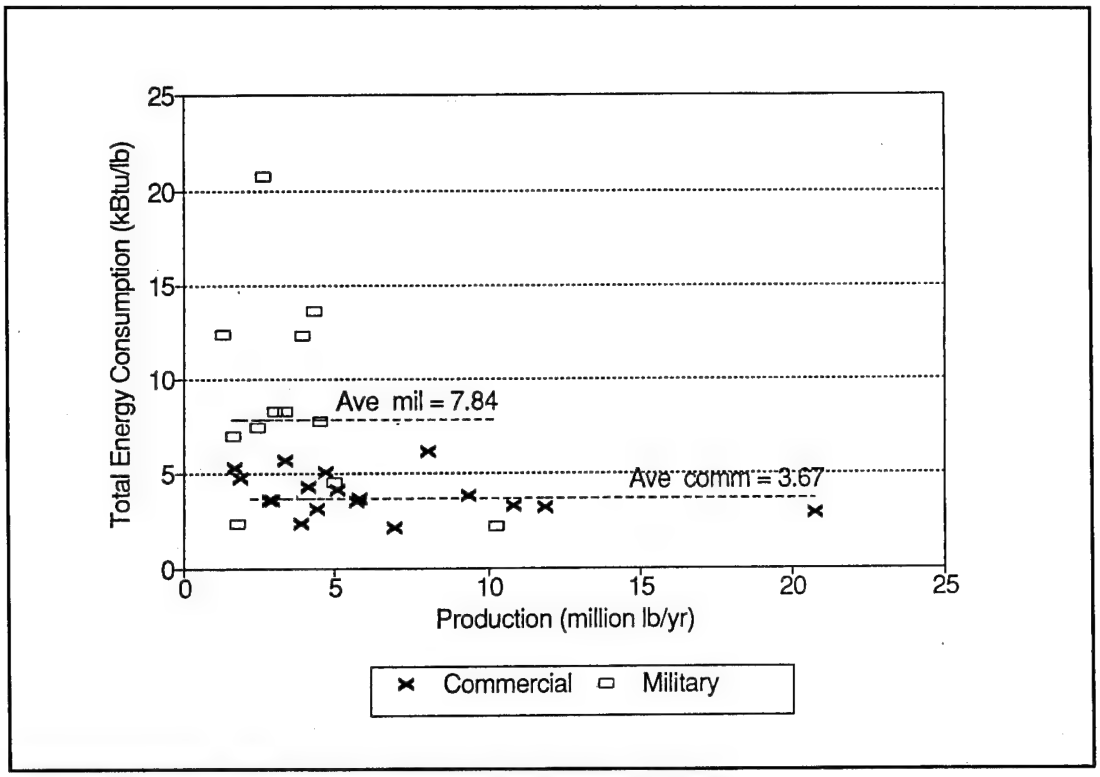


Figure 27. Total energy consumption comparison, expanded scale.

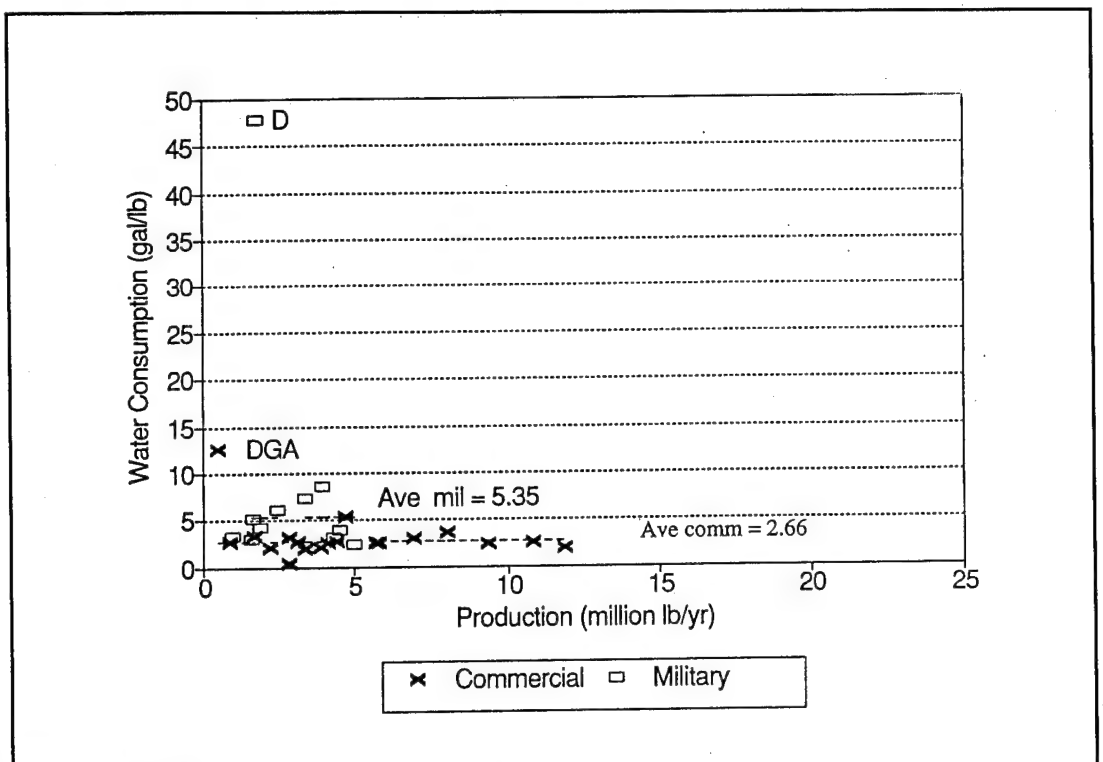


Figure 28. Water consumption comparison.

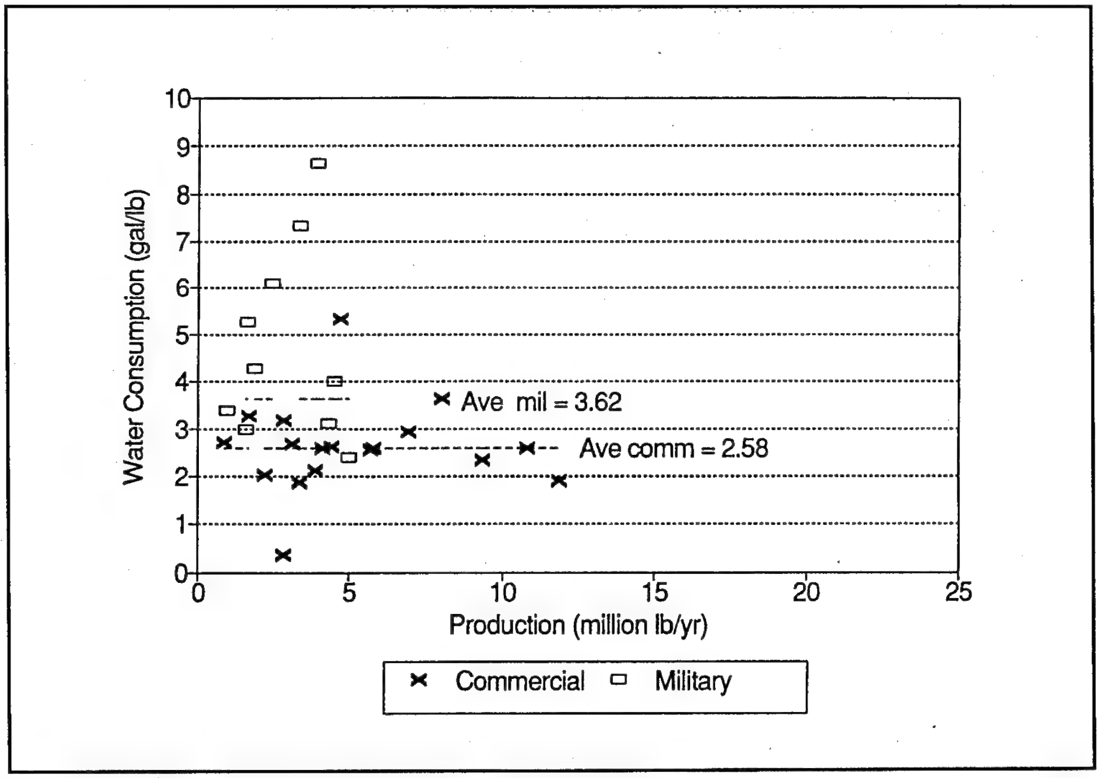


Figure 29. Water consumption comparison, expanded scale.

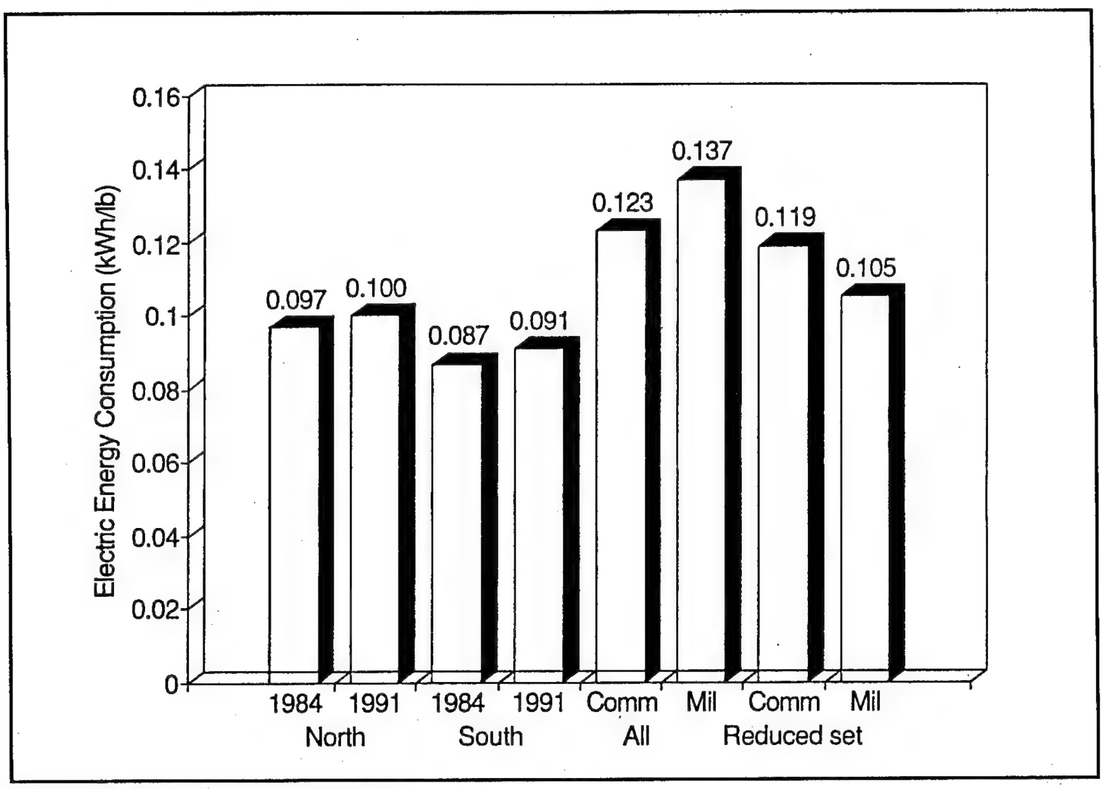


Figure 30. Electricity consumption.

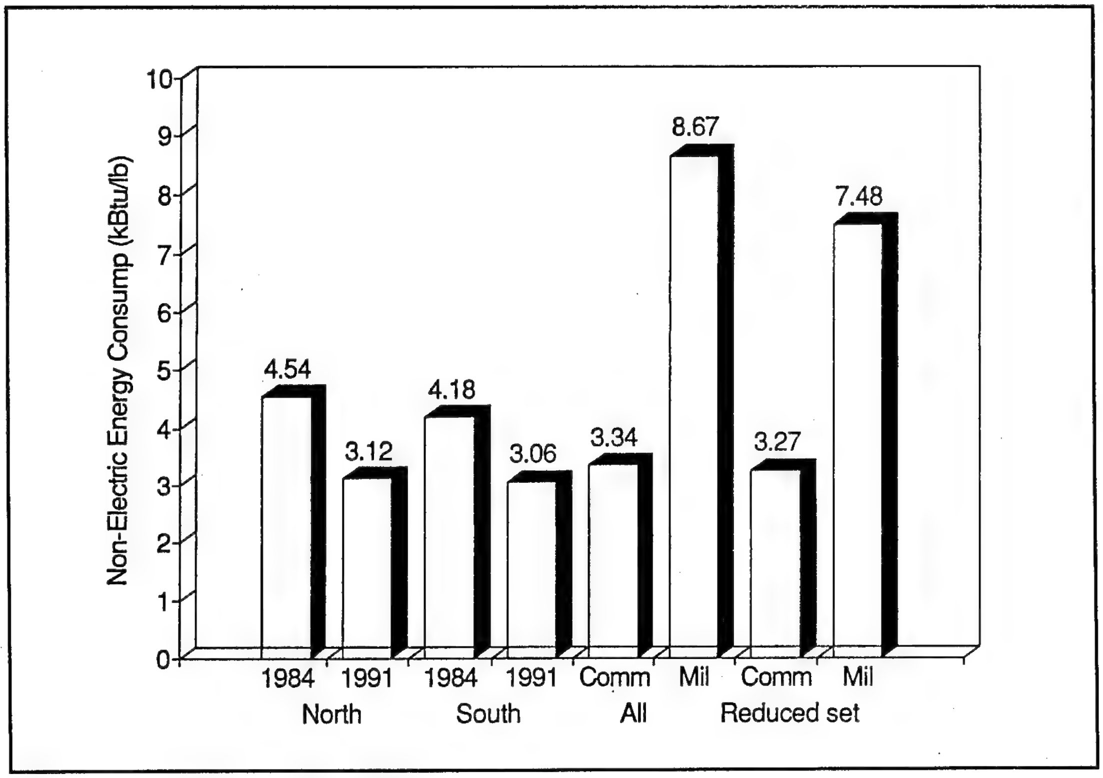


Figure 31. Nonelectric energy consumption.

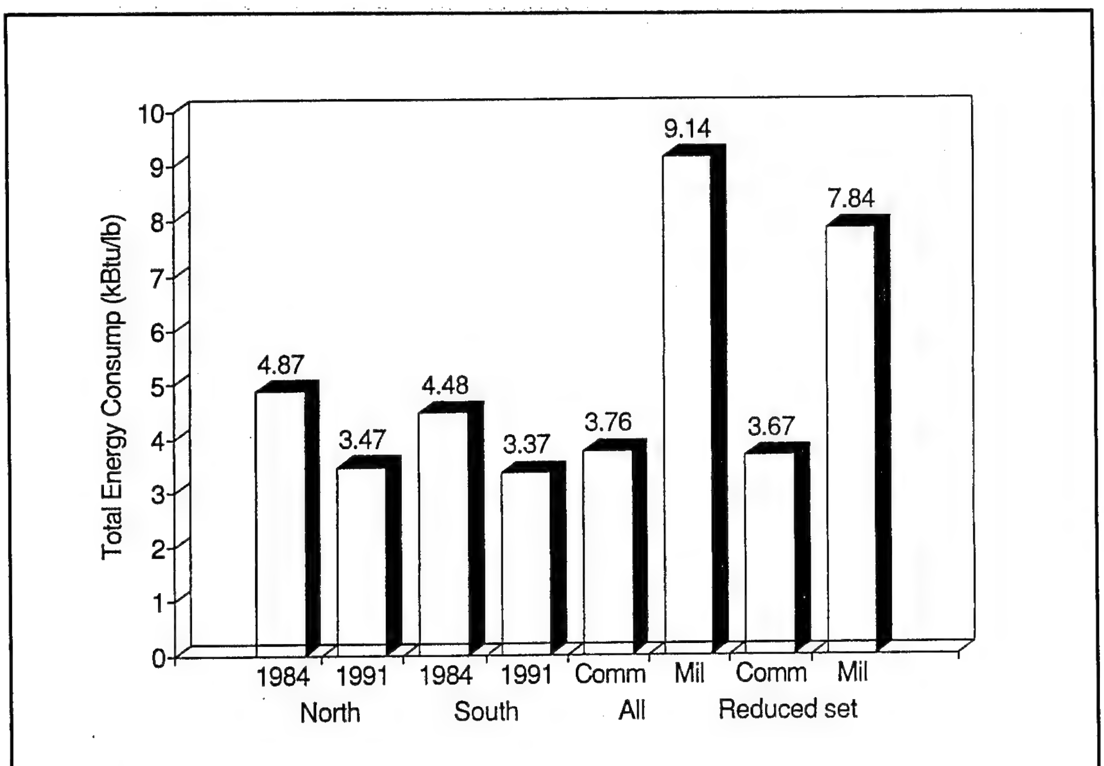


Figure 32. Total energy consumption.

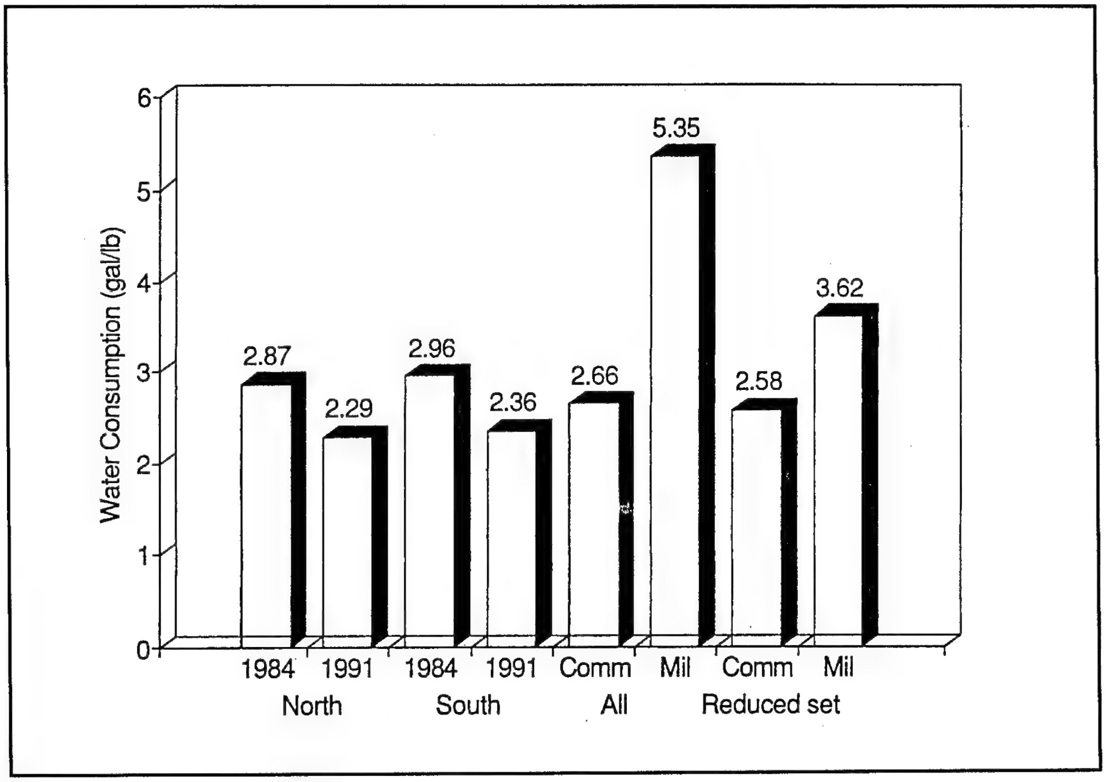


Figure 33. Water consumption.

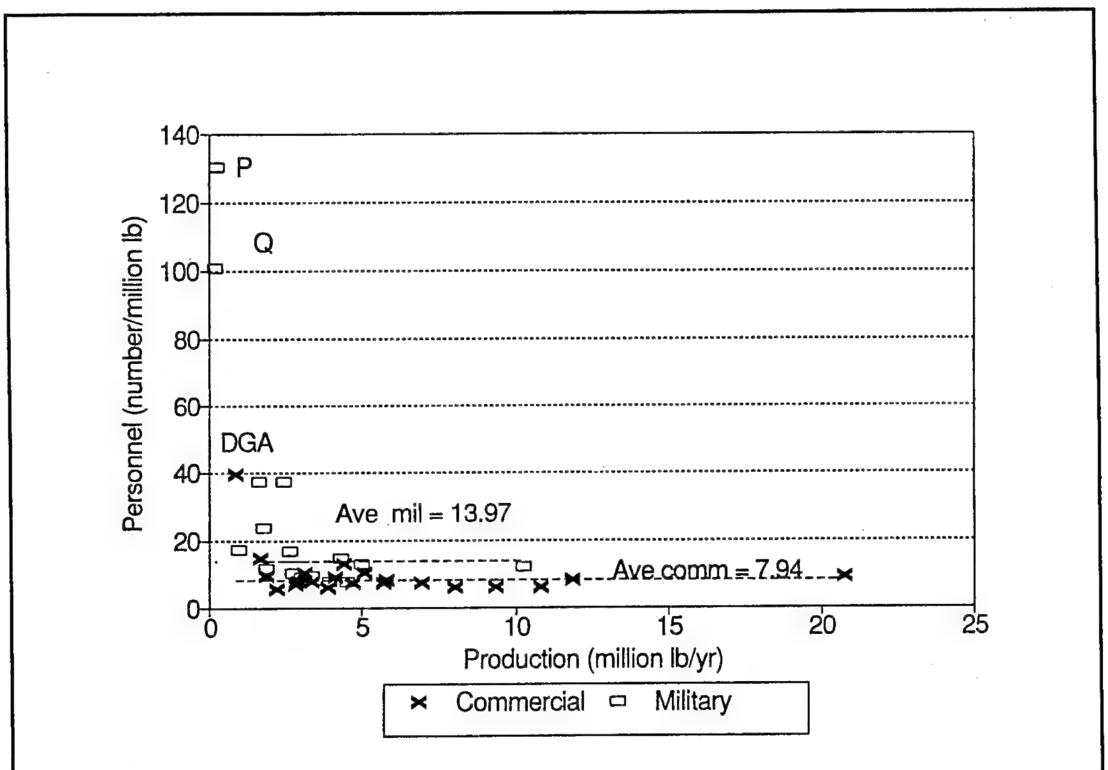


Figure 34. Personnel comparison.

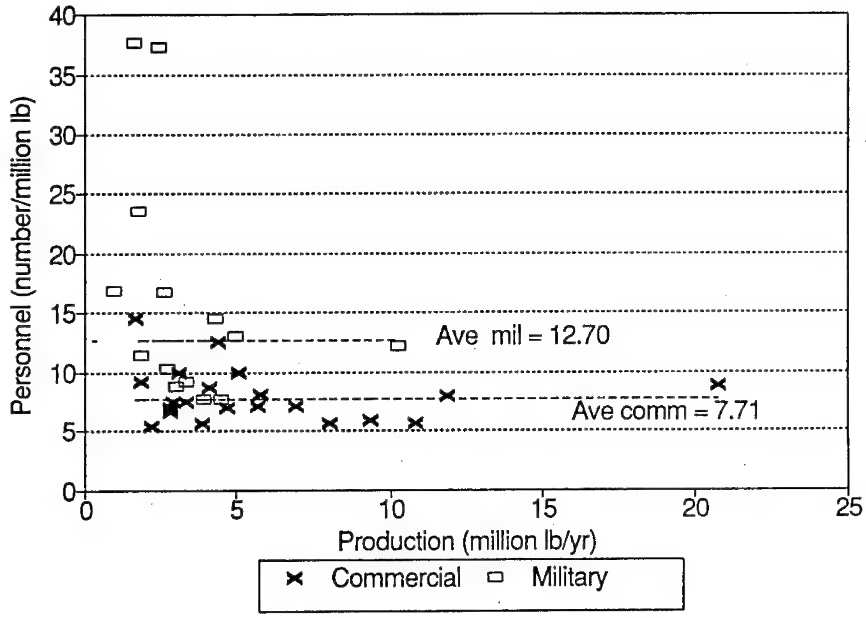


Figure 35. Personnel comparison, expanded scale.

3 Technology Review

Conventional Technologies

Unloading Batch Washers

An unloading batch washer washes and rinses one batch of laundry at a time. After washing, the batch must be removed and transferred to an extractor to continue the process. Many units can be tilted to permit easier loading and unloading. Modular installation is common since it permits simultaneous processing of different types of goods with various degrees of soiling.

Batch Extractors

An extractor removes most of the water from a freshly washed batch of laundry before the laundry goes to the drying or finishing stages. Various methods of extraction may be used, such as spinning to force the water out by centrifugal force, squeezing in a flexible container, or compressing with a hydraulically or pneumatically operated piston in a porous cylindrical container. Loads from more than one washer can be combined in the extractor operation, and loads from more than one extractor can be combined in the drying operation. Figure 36 shows a centrifugal extractor.

Washer Extractor

A washer extractor combines the washing and extracting operations into a single machine similar to a household automatic washing machine. Extraction is accomplished by spinning. Multiple speeds are available in both the wash and extraction operations to accommodate fabrics of varying delicacy. Many units can be tilted to permit easier loading and unloading. Modular installation is common, permitting flexibility in handling different types and amounts of loading. Loads from more than one washer extractor can be combined in the drying operation. Figure 37 shows a sample washer extractor.

Dryers

Dryers provide the final drying to the laundry before the finishing and ironing stages by blowing a hot gas mixture through a rotating drum (tumbler) containing the goods to be dried. Heat for drying can be provided directly by combustion of natural gas, or indirectly with a fluid such as steam, hot water, or a thermal fluid. In a direct-fired dryer, the hot exhaust gases from the combustion process are blown through the dryer. In an indirect system, a heat exchanger is employed to transfer heat from the fluid to the hot air blown through the dryer. Figure 38 shows a tumbler dryer. Where further drying beyond extraction is not required, dryers may be used without heat as tumblers, to loosen and fluff caked goods.

Energy reducing features used in dryers include exhaust gas recirculation, exhaust gas economizers, automatic detection of exhaust humidity to shut off the dryer when goods are sufficiently dry, insulation of the entire unit to retain heat in the dryer, and gravity unloading instead of pneumatic unloading with hot drying air. The lower limit of energy use for a dryer system employing all of these energy conservation features is about 1700 Btu/lb of water removed.

Flat Work Ironers

Flat work ironers are used to press flat goods such as bed linen, tablecloths, towels, etc. The main components of a flat work ironer are the chest(s) and the roller(s). The chest has a highly polished steel surface formed to the contour of the roller, and is hollow to admit steam or a thermal fluid to heat the polished steel surface to the proper temperature for drying and ironing. The roller is made of a perforated steel cylinder and is covered with a porous, heat-resistant padding and cloth. Ironing is accomplished by rolling the goods with the roller against the heated polished steel surface. The water removed from the goods is drawn to the inside of the hollow roller and exhausted out the end. In comparison with the handheld household flatiron, the roller thus performs the function of the ironing board while the heated steel surface performs the function of the iron. Figure 39 shows a flat work ironer.

Steam-heated ironers operate at maximum pressures of about 125 psia, which limits the temperature of the ironing surface to about 300 °F. Thermal fluid ironers can operate at higher temperatures, (about 400 °F) and can therefore be run at higher speeds. At the higher temperatures, more accurate control is needed to avoid scorching the goods. Both steam and thermal fluid are recirculated to the boiler or heater for reuse.

Presses

Presses are used to iron irregularly shaped goods such as shirts, blouses, and pants. The main components of a press are the buck and the head. The head has a highly polished steel surface formed to the contour of the buck, and is hollow to admit steam or a thermal fluid to heat the polished steel surface to the proper temperature for drying and ironing. The buck is a padded form on which the item to be pressed is placed. In comparison with the hand-held household flatiron, the buck performs the function of the ironing board while the head performs the function of the iron.

Utility presses have bucks that resemble household ironing boards, with flat or slightly rounded pressing surfaces. The head is contoured to match that of the buck. The garment is placed on the buck, and the head is pressed into contact with the garment. Figure 40 shows a utility garment press.

Shirt and blouse presses use a standing buck, which is dressed with the garment, and the chest closes in around it. Bucks come in different sizes and shapes that are interchangeable in the press. The inside of the buck may be pressurized with compressed air to stretch the garment to a smooth shape during the pressing operation. A porous buck and heated air may also be employed so that the hot air flowing through the garment speeds up the drying process. Figure 41 shows a double buck press.

Material Handling Systems

Material handling systems perform multiple functions of sorting, storage, and transportation of goods between the various stages of the laundering process. Material handling systems range from fully manual to fully automated. In general, as the degree of automation increases, the energy (electricity) requirement increases while the labor (number of personnel) requirement decreases. Manual systems typically consist of canvas laundry carts that are manually loaded, unloaded, and wheeled from station to station. The process is automated with conveyors, rails, and pneumatic tubes, either singly or in combination.

Conveyors can be used to transport goods to and from washers, extractors, dryers, and finishing systems. Loading and unloading can be automated through various schemes, including providing loading hoppers on tops of the machines and tilting machines to permit emptying by gravity. Figure 42 shows material handling systems featuring carts and conveyers.

Rail systems reduce required floor space by carrying goods overhead in slings. Slings, which remain as a unit throughout the washer-extractor-dryer process, are porous bags containing sorted loads of goods. This provides a convenient sorting, storage, and transportation system. If goods must be temporarily stored because of lack of machine availability, they can be kept at ceiling level, which does not interfere with personnel access to the operation. Empty slings are collapsed for storage, reducing the required rail space to a minimum. Rail systems are generally the most energy efficient of the transportation systems.

Pneumatic tubes, or *negative air systems*, are used for automatic transport from the delivery truck to the initial sorting and dispatching area and from the sorting area to the washer. When used from sorting area to washer, there is generally a "buffer" storage box of one-load capacity, which serves to minimize washer loading time. In these systems a large (25 to 60 hp) blower is used to pull the goods through a cylindrical duct to a screen box for sorting. Negative air systems are not particularly energy-conserving; their primary advantage over other transport systems is in lower first cost, installation cost, and maintenance cost. Most negative air systems are semi-automatic.

Advanced Technologies

Ozonation

The use of ozone for laundry cleaning is one of the most recent developments in the industry. The ozone-based process was developed to provide a viable cleaning method for space applications where a limited supply of resources was available to the astronauts. The process involves creating and injecting an ozone-air mixture into the wash fluid. The ozone enhances the cleaning process in several ways. The ozone oxidizes calcium and magnesium ions and contributes to the oxidation of organics to a more soluble state, promoting precipitation of the organic oxide. Washwater is recirculated through the ozone generator during the wash cycle. Overall, the action of the ozone extends the life of the detergent, decreases the amount of detergent needed, reduces the demand for water, and shortens the wash cycle time. The reduction in quantities of water and chemicals used in the wash cycle leads to a reduction in the amount of wastewater produced and a decrease in sewer expenditures. The use of extra electricity to operate the ozone generator is offset by the decrease in wash cycle time and hot water consumption. Wash cycle energy cost savings of 18 percent and chemical savings of nearly 30 percent have been predicted for systems using the ozone process.

Industry studies (Institute of Industrial Launderers [IIL] Ozone Washing Task Force, 1992) have shown that the use of the ozonation process may result in a reduction of chemical use, water consumption, and wash time while sacrificing a varying degree of cleaning capability (depending on the type of soil in the fabric). Studies also demonstrated that ozone cleaning did not exhibit any adverse effects on color retention. It has been noted, however, that ozone may accelerate the fading of some fabrics, such as dyed acetate fabrics. Also, fabric strength was not significantly affected during the ozone cleaning tests. Additional studies to investigate the effect of varying concentrations of ozone on the cleaning process have been planned by various organizations.

Ozone is also useful in removing odors from fabrics. The odor-causing substance is neutralized via oxidation by the ozone molecules. Everyone working with ozone systems must be cautious, because concentrations as low as only one part per million have toxic effects on humans. Symptoms of exposure to ozone include headache, dry throat, irritation of respiratory passages, and burning eyes. Exposure to extremely high concentrations of ozone can be lethal. Ozone, though colorless, can be detected by sensors and has a distinct odor detectable to humans. Workers should evacuate the area when dangerous levels of ozone are present.

Microwave Dryers

The success of microwave technology for cooking created interest in the possibility of microwave drying. The process of using microwaves for drying fabrics has been, and continues to be, tested to determine its effectiveness, efficiency, and safety. Initial tests revealed problems with heating and arcing of metal (snaps, zippers, buttons, rivets), which damaged the fabric being dried and presented the possibility of ignition. Subsequent testing has shown that a drying process involving microwaves and heated air may be more efficient than conventional drying. Also, drying with microwave energy occurs at a lower temperature than conventional drying, allowing the consumer to dry delicate fabrics without shrinkage or other damage. The problem of arcing and overheating certain materials may be eliminated by controlling the intensity of the electric field strength in the dryer. Near the end of the drying cycle, the field strength in the dryer increases as the humidity level decreases, causing an increase in the possibility of overheating materials in the dryer. Incrementally decreasing the power from the microwave emitters as the humidity of the exit air decreases near the end of the drying cycle would, conceivably, lessen the possibility of overheating and arcing. The production of microwave dryers for general use will be feasible when the overheating and arcing problems have been solved.

Continuous Batch Washers

In a continuous batch washer (CBW), each step of the wash/rinse process takes place in a separate module of the machine. The goods are automatically transferred between the modules on the appropriate schedule. The amount of chemicals and water added to each module is controlled by a preprogrammed microprocessor. The laundry operator must enter the programming code for the type of goods being laundered (whites, colors, towels, etc.) and the machine then washes the batch. Since the modules operate simultaneously, several loads of goods can be in different stages of the process at the same time. Time savings occur because the CBW operates continually, with one batch following directly after another through the modules, eliminating the necessity of waiting for draining and refilling a single cylinder as in the case of a conventional batch washer. Clean water is fed to the machine at the final rinse module, and then is transferred through the row of modules in a "counterflow" direction to the goods. This ensures the cleanest possible goods at the end of the process. Water is recycled through the system to extend the life of the chemicals, reduce water consumption, and reduce energy requirements for water heating. CBWs use less water and energy than batch washers. Figure 43 shows a CBW schematic.

CBWs are used in laundry plants today in Europe, North America, and elsewhere. The process was developed to accommodate energy, water, and labor problems experienced in Europe. Environmental restrictions, water and energy shortages, and increases in the cost of energy, water, and labor have created a need for more efficient laundry systems throughout the world. CBWs answer the need for more efficient, less costly, and reliable equipment technology. The quality of cleaning occurring in a CBW is equal to or better than that achieved in a conventional batch washer. In most, if not all, CBW installations, the goods are automatically transferred through the entire laundering process to the final finishing stages. Labor savings occur because the only labor required is to load the CBW feeder and enter the proper programming code.

Thermal Fluid Systems

Thermal fluid systems provide an alternative to steam/hot water systems for providing thermal energy. Flat Work ironers are the most common application of thermal fluid systems in laundry facilities. These systems may also be used to provide energy for heating water, presses, and air (space heaters and dryers). The thermal fluid systems, when properly operated, require less maintenance than steam systems and may be more energy efficient due to the elimination of losses associated with steam blowdown, deaeration, and trap leaks. Corrosion problems common to steam systems are not present in thermal fluid systems. Thermal fluid systems do not require steam traps, water treatment chemicals, or deaeration. Thermal fluid spills or leaks are treated

like lubricating oil leaks and the thermal fluid can be combined with used oils for recycling. Steam systems are usually operated at temperatures as high as 350 °F and a pressure of 125 psi while thermal fluid systems can safely operate at temperatures as high as 450 °F near atmospheric pressure. A small amount of pressure is created by the pump that circulates the fluid. Thermal fluid systems can use a cold-sealed expansion tank or inert gas blanketing to prevent oxidation of the fluid. Safeguards should also be taken to prevent degradation of the fluid via overheating, especially during equipment shutdowns or power failures. Oxidation and degradation of the fluid will decrease the system's performance and could even damage the system. A licensed operating engineer is required in many states by operations employing high pressure steam systems. The thermal fluid systems usually do not require a licensed operating engineer, a factor that significantly reduces labor costs.

Direct Contact Water Heaters

In a fuel-fired (as opposed to electric) water heater, water is heated from the hot exhaust gases of the fuel combustion process. In a conventional heater, the water and exhaust gases are physically separated by some configuration of solid walls (e.g., shell-and-tube, fire-tube, or water-tube). In direct contact water heaters, the water is placed in direct contact with the exhaust gases. The contact occurs in a packed tower configuration, in which the water is injected at the top of the tower (typically through spray nozzles or a ring-type manifold) with the exhaust gases flowing upward through the packing. As thin films of water trickle down the packing, they pick up heat through direct contact with the rising exhaust gases. The direct contact heat transfer process is very efficient, with the exhaust gases typically at a final exit temperature within 20 °F of the entering water temperature. At the low exhaust gas exit temperature, the water vapor in the exhaust gases has been condensed and added to the water supply—an additional bonus. Efficiencies greater than 99 percent are claimed. Figure 44 shows a sample direct contact water heater.

In steam-generation boilers, a direct contact heat exchanger having essentially the same configuration as the direct contact water heater described above can be used in the exhaust stack to preheat the boiler feed water. In a well-tuned boiler, this can decrease the fuel requirements by 20 percent compared to a system with no exhaust heat recovery.

Waste Water Heat Recovery and Rinse Water Reuse

In a wastewater heat recovery system, thermal energy in the wastewater from wash-and-rinse operations is used to preheat the incoming supply water. This is accom-

plished with a liquid-liquid heat exchanger located between the water supply and wastewater lines.

Rinse water reuse can also be incorporated with waste heat recovery to reduce water usage. In this system, relatively uncontaminated final rinse water is collected and reheated for use in the first washing stages of operation. The amount of reusable water available depends on the type and level of soiling in the laundry. Typical water savings range between 20 and 30 percent. Filters are included to removed solid contaminants from the reclaimed rinse water. If a plant already has a wastewater heat recovery system, no additional energy savings are provided with a rinse water reuse system.

Companies/Organizations

Table 2 lists manufacturers of various types of laundry equipment. Table 3 lists resource use requirements for washers and extractors. Table 4 lists resource use requirements for dryers, flat work ironers, and presses. Manufacturers should be contacted directly for updated laundry equipment, specifications, and product availability.

Table 2. Laundry equipment manufacturers.

Company Name	Water Heating Equipment	Sorting Systems	Wash Room Equipment				Dryers				Flat Work Systems	Presses	Material Handling Systems	
			Continuous Batch Washer (CBW) Systems	Washer Extractors	Batch Washers; Batch Extractors	Waste Water Energy Recovery	Gas; Steam; Thermal Fluid	Electric	Lint Collection Devices	Energy Recovery Devices			Rail Systems; Conveyor Systems	Negative Air Systems
American Dryer							✓	✓						
American Laundry Machinery				✓	✓	✓	✓				✓		✓	✓
Ajax												✓		
Boewe Passat			✓		✓		✓							
G.A. Braun				✓			✓		✓		✓			
Brim Laundry Machinery					✓									
Central Finishing Systems											✓			
Cissel Manufacturing								✓						
Clean Cycle Systems Division of Techni-Quip									✓	✓				
Ekola Engineering		✓											✓	
Ellis					✓									
Energenics									✓	✓				
Forenta												✓		
Huebsch Originators							✓	✓						
Jensen											✓			
Kemco Systems	✓					✓								
Lavatec			✓		✓		✓							
Ludell Mfg.	✓					✓								
Pellerin Milnor			✓	✓			✓		✓				✓	
Speed Check Conveyor		✓											✓	
Thermal Engineering of Arizona	✓					✓				✓				
Unipress												✓		
Washex/Senking ELX Group			✓	✓			✓		✓	✓				
White Automation		✓											✓	

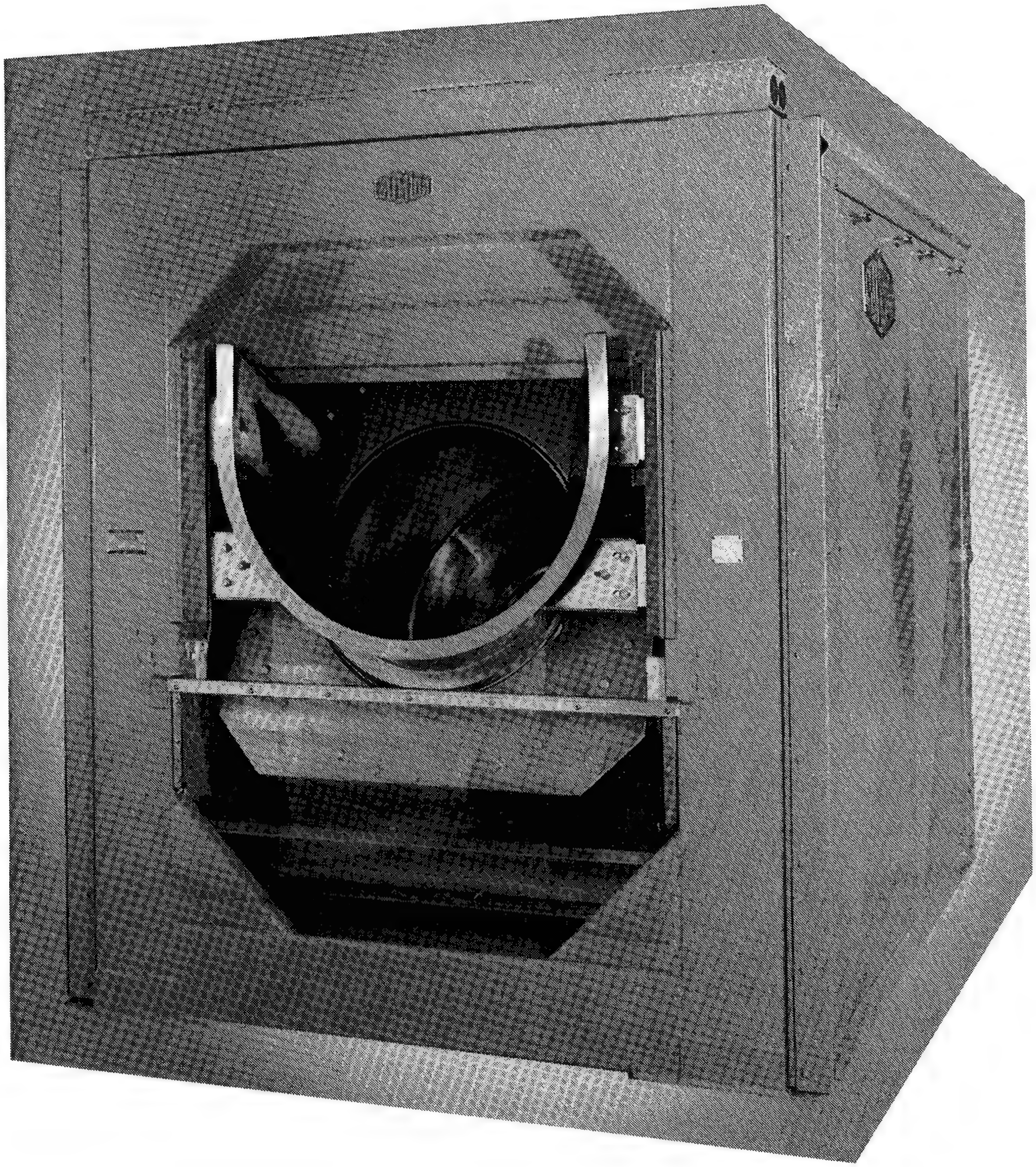
Table 3. Energy, water, and steam use by washers and extractors.

	CBW Systems				Washer Extractors					Batch Washers				Batch Extractors			
	Boewe Passat	Lavatec	Pellerin Milnor	Washex/ Senking	American Laundry	G.A. Braun	Pellerin Milnor	Washex/ Senking	Lavatec	American Laundry	Boewe Passat	Brim Laundry	Ellis	American Laundry	Boewe Passat	Brim Laundry	Ellis
Capacity (lb/hr)	880	1100	2000	1100	300	300	300	300	450	1200		1200	1200	2400		2400	
Cycle Time (min)	30	30	30	30	50	50	50	50	50	40		40	40	5		5	
Electricity Use (kWh/hr)			42.4	14.2	5.7		6.0	6.5		1.7				10		10	
Max Electric Draw (kW)			60.6	15.6	13.5		16.9		21	20				15		15	
Water Use (gal/lb)	1.1	1.1	1.1	1.1	3.5	3.5	3.5	3.5	3.5	3.5		3.5	3.5				
Water Temp. (°F)	90	90	90	90	70-170	70-170	70-170	70-170	70-170	70-170	70-170	70-170	70-170				
Steam Use (lb/lb)	0.6	0.6	0.65	0.5	1.5*			1.5*									
Steam Press. (psia)	75	75	75	70	100					80							
Steam Temp. (°F)	320	320	320	300	335					325							
Expected Lifetime (years)	15	15	15	15	15					15				15			
Number in Use—USA	60	75	245	30													
Number in Use—Worldwide	500	500	630	400													

* Steam use in washer extractors depends on the temperature of hot water available. 1.5 lb of steam/lb of laundry is typical for raising the temperature of 2 baths by 100 °F.

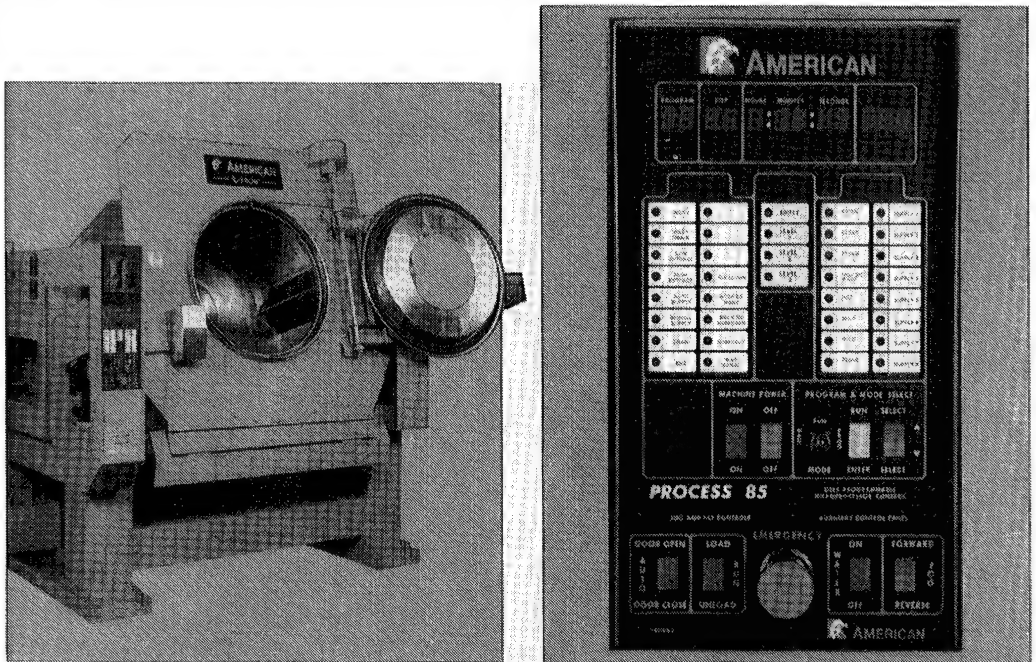
Table 4. Energy, water, and steam use by dryers, flat work ironers, and presses.

	Dryers					Flat Work Ironers				Presses		
	American Laundry	Boewe Passat	G.A. Braun	Lavetec	Pellerin Milnor	American Laundry	G.A. Braun	Central Finishing	Jensen	Ajax	Forenta	Unipress
Capacity (lb/hr)	450/200	220		450/200	220							
Cycle time (min)	20/35	20		25/20	20	110 fpm	110 fpm	110 fpm	110 fpm	30 sec	30 sec	30 sec
Electricity use (kWh/hr)	17.3/6.56					14.7				5.7	0.18	0.36
Max electric draw (kW)	23/9.56	7.9			11	18	20	18	17	6.8	0.18	0.36
When Using Gas												
Use (Btu/lb water removed)	1900/2100	1.73		2100/								
When Using Steam												
Use (lb/lb water removed)	1.80/1.95	1.73				1.7	1.7	1.6	2.0	2.55	3.1	2.3
Pressure (psig)	100/100	147				125	125	125	125	125	125	125
Temperature (°F)						350	350	350	350	350	350	350
When Using Hot Water												
Use rate (gal/lb)												
Temperature (°F)		392										
When Using Thermal Fluid												
Use Rate (MBtu/hr)						1.50			1.500			
Temperature (°F)		437				450			450			
Expected lifetime (years)	15	15		15		25	25	25	25	10	10	10
Number in use - USA												
Number in use - worldwide												



(Source: Pellerin Milnor Corporation, 1992. Reprinted by permission.)

Figure 36. Milnor centrifugal extractor.

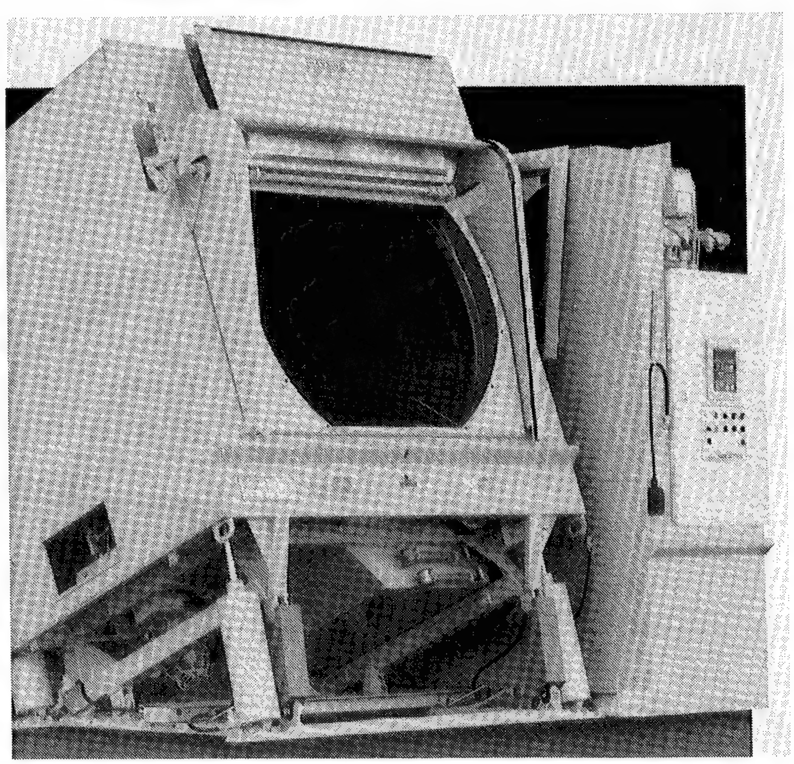


Large open-area cylinder of 450 L-tron takes a true 450 Lb. load.

Process 85 Microprocessor Control monitors all washer/extractor operations.

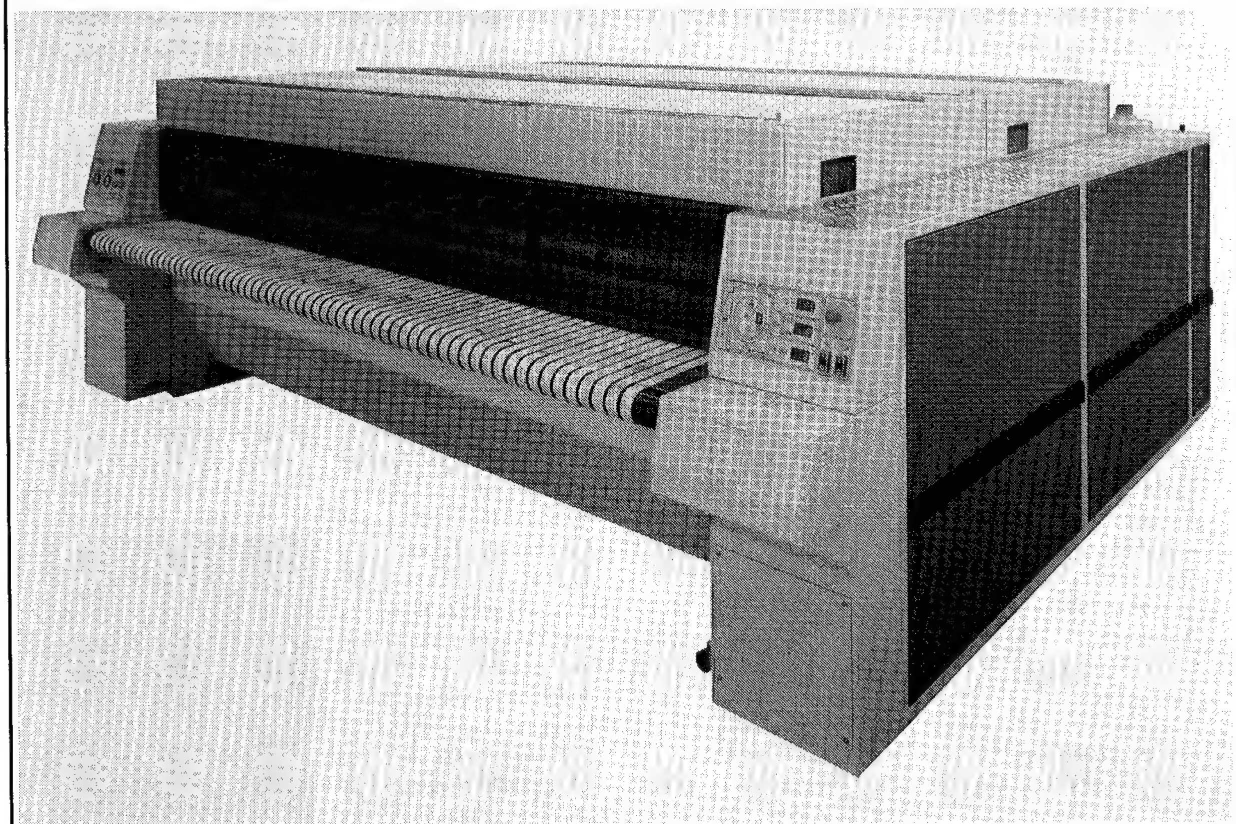
(Source: American Laundry Machinery, Inc. Reprinted by permission.)

Figure 37. American washer extractor.



(Source: Challenge Industries, Inc., 1992. Reprinted by permission.)

Figure 38. Challenge Pacesetter dryer.

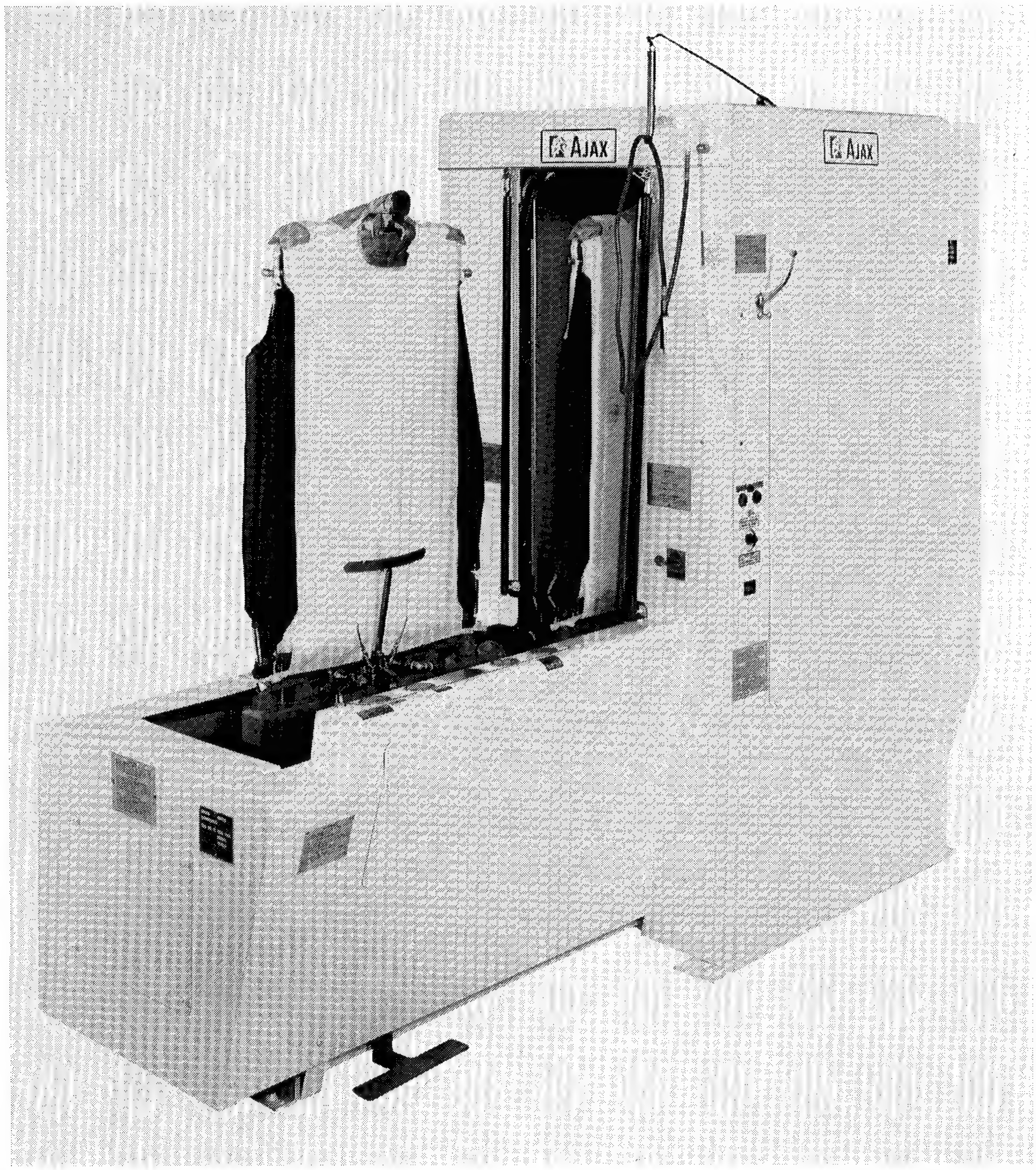


(Source: Central Finishing Systems. Reprinted by permission.)

Figure 39. Central flat work ironer.

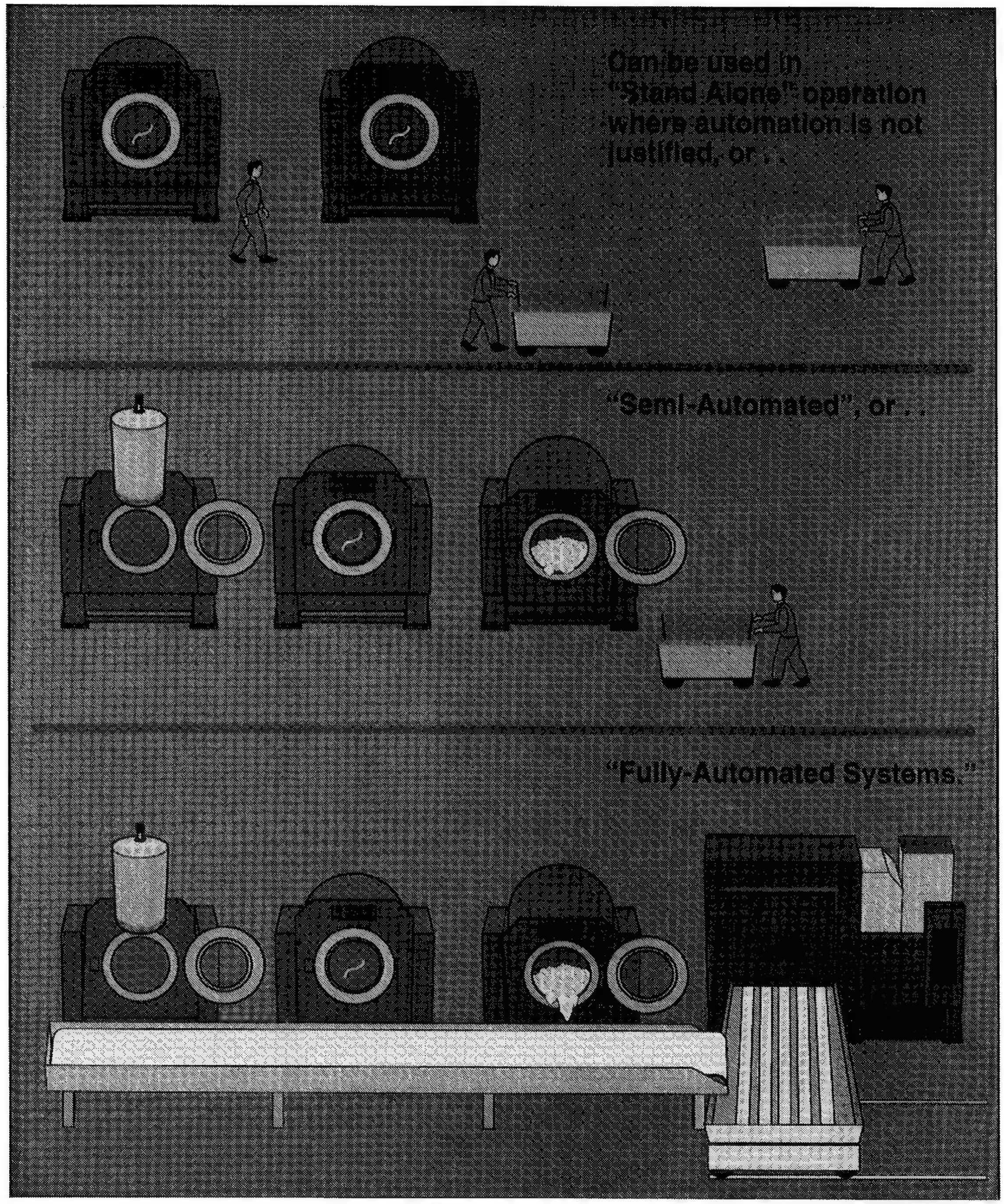
(Source: Ajax Division, American Laundry Machinery, Inc. Reprinted by permission.)

Figure 40. Ajax utility garment press.



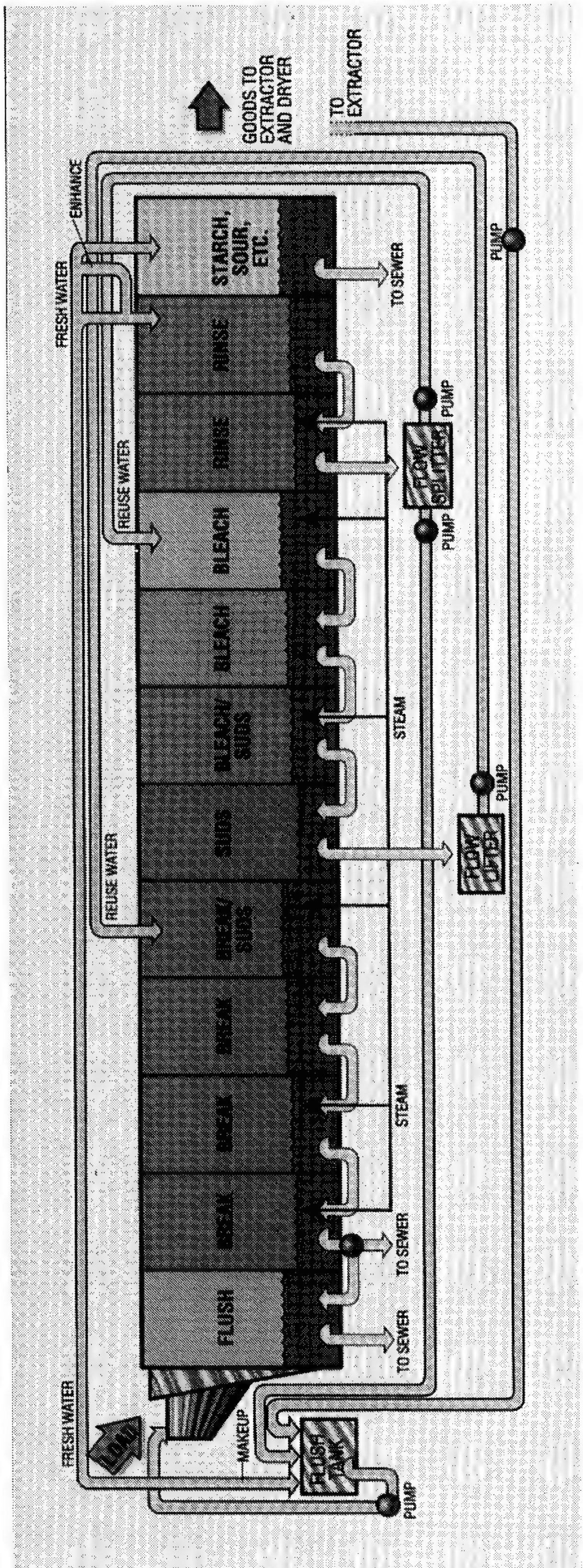
(Source: Ajax Division, American Laundry Machinery, Inc. Reprinted by permission.)

Figure 41. Ajax double buck cabinet bosom, body and yoke press.



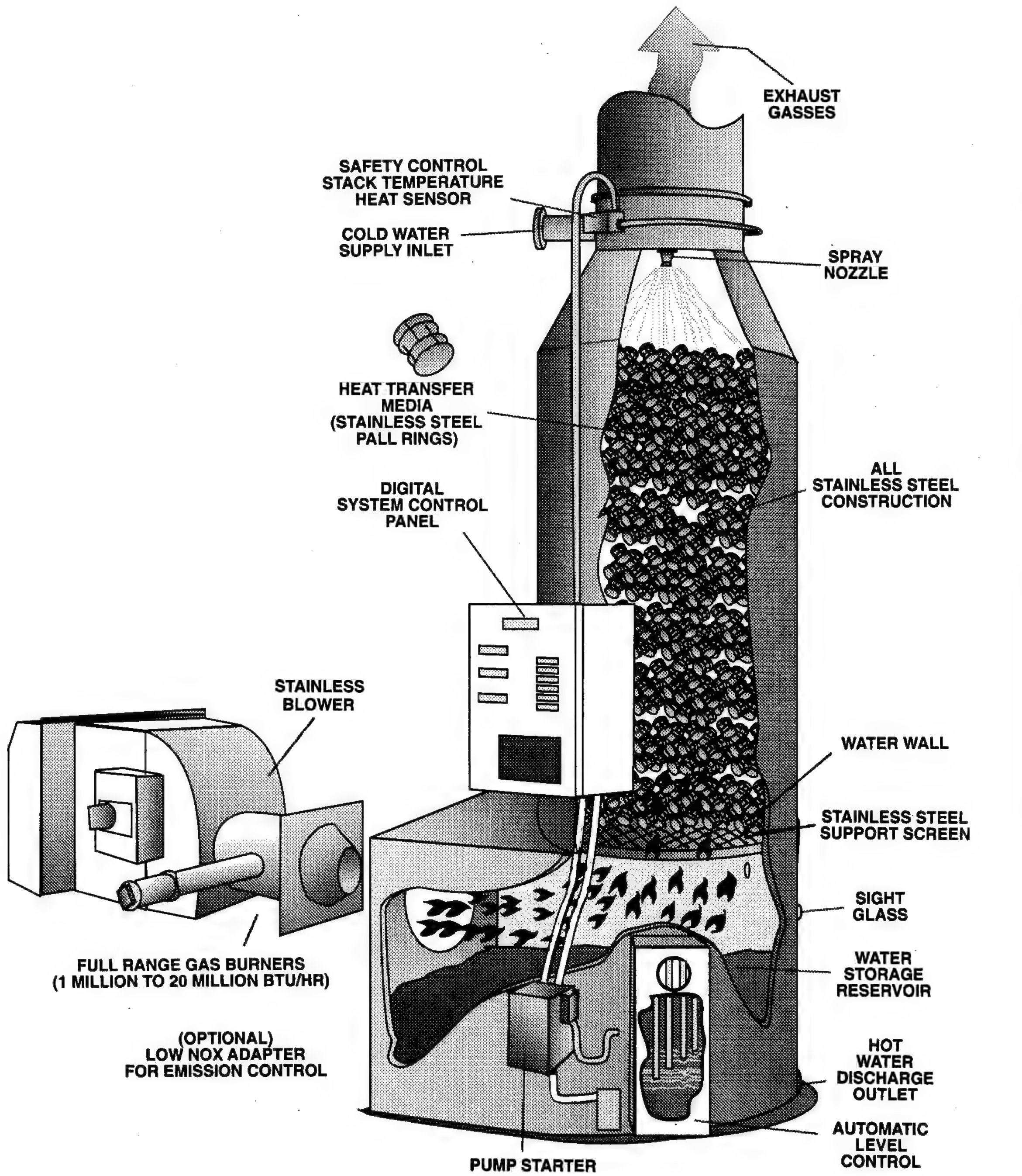
(Source: American Laundry Machinery, Inc. Reprinted by permission.)

Figure 42. Laundry automation systems.



(Source: Pellerin Milnor Corporation, 1993. Reprinted by permission.)

Figure 43. Milnor continuous batch washer schematic.



(Source: Ludell Manufacturing Company. Reprinted by permission.)

Figure 44. Ludell direct contact water heater.

4 Laundry Process Models

Model laundry facilities were developed to provide a way to compare conventional laundry facilities with those using more advanced technologies. The model facilities, sized according to production in pounds per year, are categorized as: less than 1,000,000 lb/year (small); 1,000,000 to 3,000,000 million lb/year (medium); greater than 3,000,000 lb/year (large). Three models were developed for each of three size ranges. The models include a conventional facility similar to the existing DOD facilities, a high efficiency facility, and a super (ultra) high efficiency facility. Most DOD installations maintain equipment inventory lists of model, capacity, and age information for laundry facilities. The equipment lists from DOD laundry facilities generally reflect those found in the conventional model facilities. Tables 5 and 6 list equipment for medium conventional and medium high efficiency model facilities. Appendix E contains predicted energy and water consumption data, predicted utility cost data, and proposed laundry operating timetables for conventional, high efficiency, and ultra high efficiency (designated SOA2) laundry models.

Comparison With Military and Commercial Facilities

Figure 45 shows predicted electricity consumption for the model facilities and electricity consumption for the commercial and military facilities. The predicted electricity consumption for the conventional model facilities agrees with that reported for both commercial and military facilities. The predicted electricity consumption for the high efficiency and super high efficiency models is slightly higher than that reported for both commercial and military facilities. This may be due, in part, to increased use of electricity in advanced control systems.

Figure 46 shows predicted nonelectric energy consumption for the model facilities and nonelectric energy consumption for the commercial and military facilities. The predicted nonelectric energy consumption for the conventional model facilities agrees with that reported for military facilities. The predicted nonelectric energy consumption for the high efficiency and super high efficiency models falls within the range reported for commercial facilities. These findings support the field observations of conventional (older) equipment at military facilities and newer (modern) equipment being used in commercial laundries.

Table 5. Equipment list for a medium conventional model facility.

Item	Description
A	Sorting conveyer
B	Soil storage rail
C	400-lb washer extractor
D	200-lb washer extractor
E	100-lb washer extractor
F	Peristaltic pump supply system
G	200-lb gas-fired dryer
H	100-lb gas-fired dryer
J	Spreader feeder
K	8-roll super sylon ironer
L	Double lane primary/cross folder
M	Flow rack
N	Small piece folder
P	Small piece folder
R	70-hp dual-fired boiler
S	Deaerator return system
T	Water softener
U	10 hp air compressor
V	Gas-fired hot water heater
W	Air dryer
X	Double buck shirt press
Y	Sleever
Z	Collar cuff press
AA	Utility press
BB	Clean take-away conveyer

Table 6. Equipment list for a medium high efficiency model facility.

Item	Description
A	9-chamber, 50-lb, mini-continuous batch washer
B	Single stage system press
C	C.B.W. system shuttle conveyer
D	C.B.W. system 100-lb dryers
E	200-lb dryer
F	150-lb gas-fired dryer
G	75-lb gas-fired dryer
J	125-lb solid mount washer extractor
K	50-lb washer extractor
L	200-lb washer extractor
M	Two roll 32-in. (or 27-in.) steam-heated ironer
N	Two-lane combination primary/single lane crossfolder w/stacker
P	Small piece folding table w/cart dumper
P1	Blanket folding table w/dumper
Q	Four-station spreader feeder
R	Clean work take-away conveyer
S	10-hp air compressor w/tank
T	Compressed air dryer
U	Water softener w/brine tank
V	Gas-fired water heater
W	70-hp gas/oil-fired steam boilers
X	Boiler return system
Y	Five-pocket loading conveyer
Z	Cart dumper (shown w/cart)
AA	Domestic washer
BB	Domestic dryer
CC	Garment steam finisher (tunnel)
DD	Combination quarter/french small piece/gown folder

Figure 47 shows predicted total energy consumption for the model facilities and total energy consumption for the commercial and military facilities. The predicted total energy consumption for the conventional model facilities falls within the range reported for military facilities. The predicted total energy consumption for both high efficiency and super high efficiency models falls within the range reported for commercial facilities. Again, these findings support the field observations of conventional (older) equipment in service at military facilities and newer (modern) equipment in service at commercial laundries.

Figure 48 shows predicted water consumption for the model facilities and water consumption for the commercial and military facilities. The predicted water consumption for the conventional model facilities falls within the range reported for military facilities. The predicted water consumption for both high efficiency and super high efficiency models falls within the range reported for commercial facilities. Again, these findings support the field observations of conventional (older) equipment in service at military facilities and newer (modern) equipment in service at commercial laundries.

Small Facilities (510,000 lb/year)

Due to equipment size limitations, the conventional facility and the high efficiency facility for the smallest size range (less than 1,000,000 lb/year) are essentially the same and are represented identically. Therefore, only two options, a conventional/high efficiency model and a super high efficiency model, were actually presented for the small facility modeling. Figure 49 shows annual utility usage and Figure 50 a conceptual layout for the small conventional/high efficiency laundry. Figure 51 shows the annual utility usage for the small super high efficiency model, and Figure 52 shows the conceptual layout for the small super high efficiency laundry. Small military facilities with older conventional equipment and controls could reduce nonelectric energy consumption by 27.6 percent by using modern, super high efficiency equipment at the cost of only a small (4.6 percent) increase in electricity use. The electricity use increases because modern controls and energy conservation equipment designed to reduce nonelectric energy consumption consume more electricity than conventional equipment with more rudimentary controls. A reduction of 3.7 percent in water consumption can be expected when upgrading conventional small facilities with super high efficiency equipment. The reduction in water and nonelectric energy are achieved via the addition of a wastewater heat reclamation system and an ozone generator.

Medium Facilities (1,800,000 lb/year)

Figure 53 presents the annual utility usage for the medium conventional model and Figure 54 shows a possible layout for the medium conventional laundry. Figure 55 shows the annual utility usage for the medium high efficiency model, and Figure 56 depicts a possible layout for the medium high efficiency laundry. Figure 57 shows the annual utility usage for the medium super high efficiency model and Figure 58 depicts a possible layout for the medium super high efficiency laundry. Medium military laundry facilities with older conventional equipment and controls could reduce nonelectric energy consumption by 44.5 percent by employing high efficiency equipment while increasing electricity use by only 1.3 percent. Most of the reduction in energy and water use is due to the addition of the continuous batch washer.

Medium military laundry facilities with older conventional equipment and controls could reduce nonelectric energy consumption by 53.7 percent by employing modern, super high efficiency equipment while increasing electricity use by 7.0 percent. The additional energy savings realized in the super high efficiency plant are attributed to the addition of wastewater heat reclamation and an ozone generator. A reduction of 51.1 percent in water consumption can be realized when upgrading medium conventional military facilities with high efficiency or super high efficiency equipment. The medium super high efficiency model yields a greater reduction in nonelectric energy consumption than the medium high efficiency model, but provides no additional reduction in water consumption since water use is already minimized by the continuous batch washer.

Large Facilities (5,000,000 lb/year)

Figure 59 presents the annual utility usage and Figure 60 shows a possible layout for the large conventional laundry. Figure 61 shows the annual utility usage and Figure 62 shows a possible layout for the large high efficiency laundry. Figure 63 shows the annual utility usage and Figure 64 shows a possible layout for the large super high efficiency laundry. Large military laundries with older conventional equipment and controls could reduce nonelectric energy consumption by 62.2 percent by employing high efficiency equipment while increasing electricity use only slightly (1.2 percent). Most of the reduction in energy and water use is due to the addition of the continuous batch washer system.

Large military laundry facilities with older conventional equipment and controls could reduce nonelectric energy consumption by 69.7 percent by using modern, super high efficiency equipment while increasing electricity use by only 8.5 percent. The

additional energy savings realized in the super high efficiency plant are attributed to the addition of wastewater heat reclamation and an ozone generator. Upgrading large conventional military facilities with high efficiency equipment can reduce water consumption by 58.1 percent. The addition of super high efficiency equipment may yield a 58.7 percent reduction in water consumption.

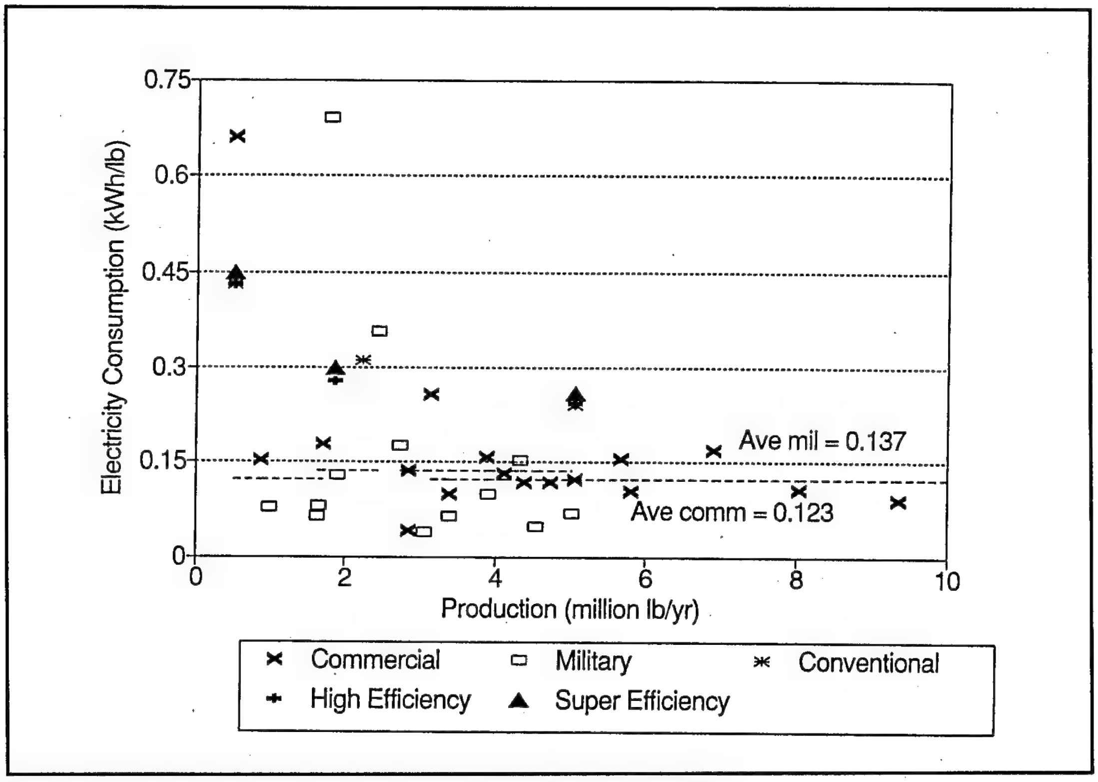


Figure 45. Electricity consumption comparison with model facilities.

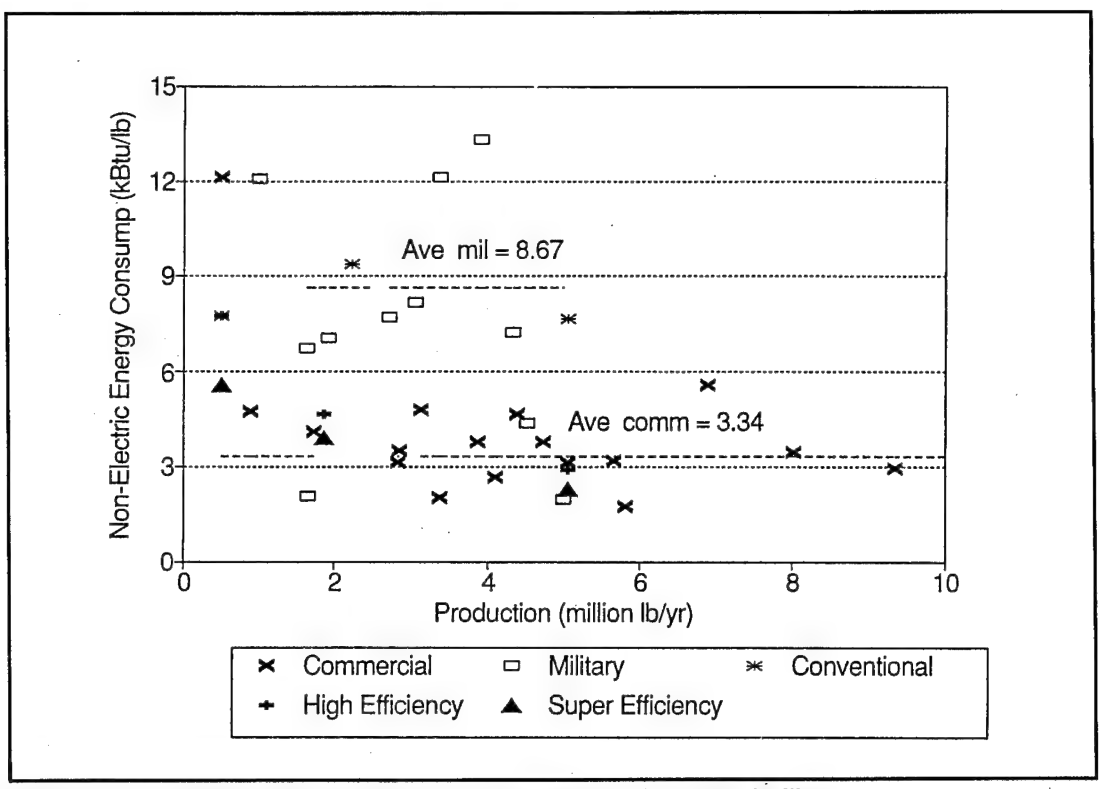


Figure 46. Nonelectric energy consumption comparison with model facilites.

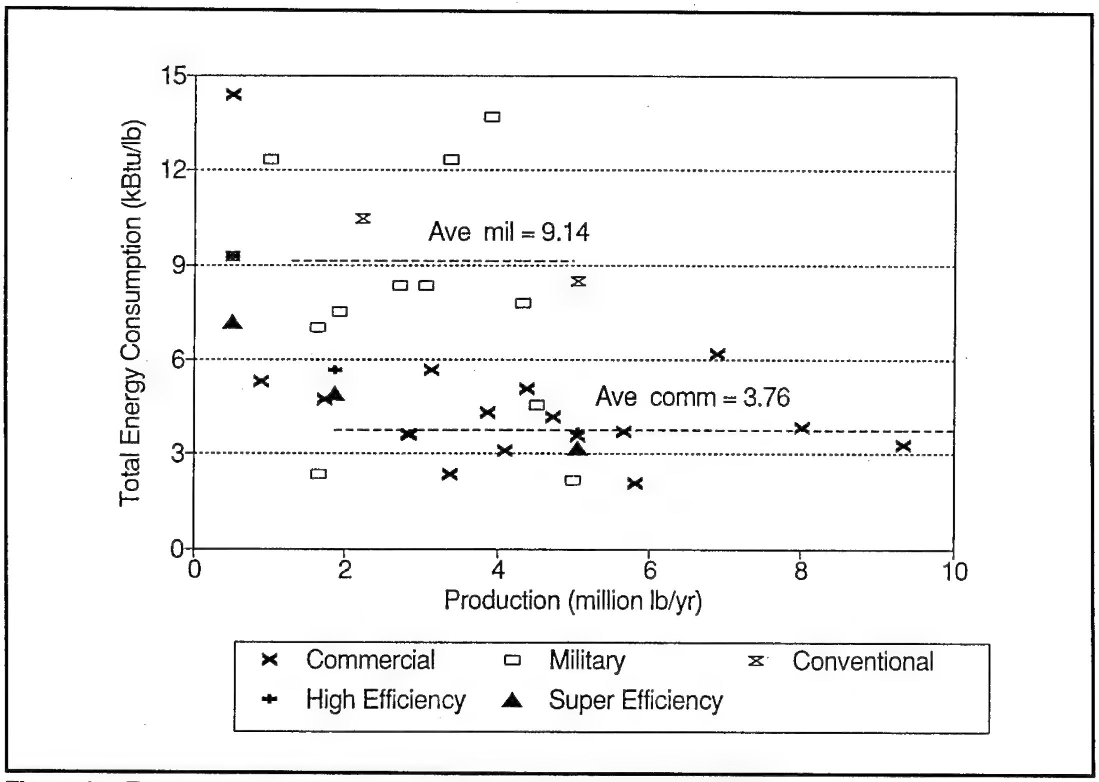


Figure 47. Total energy consumption comparison with model facilities.

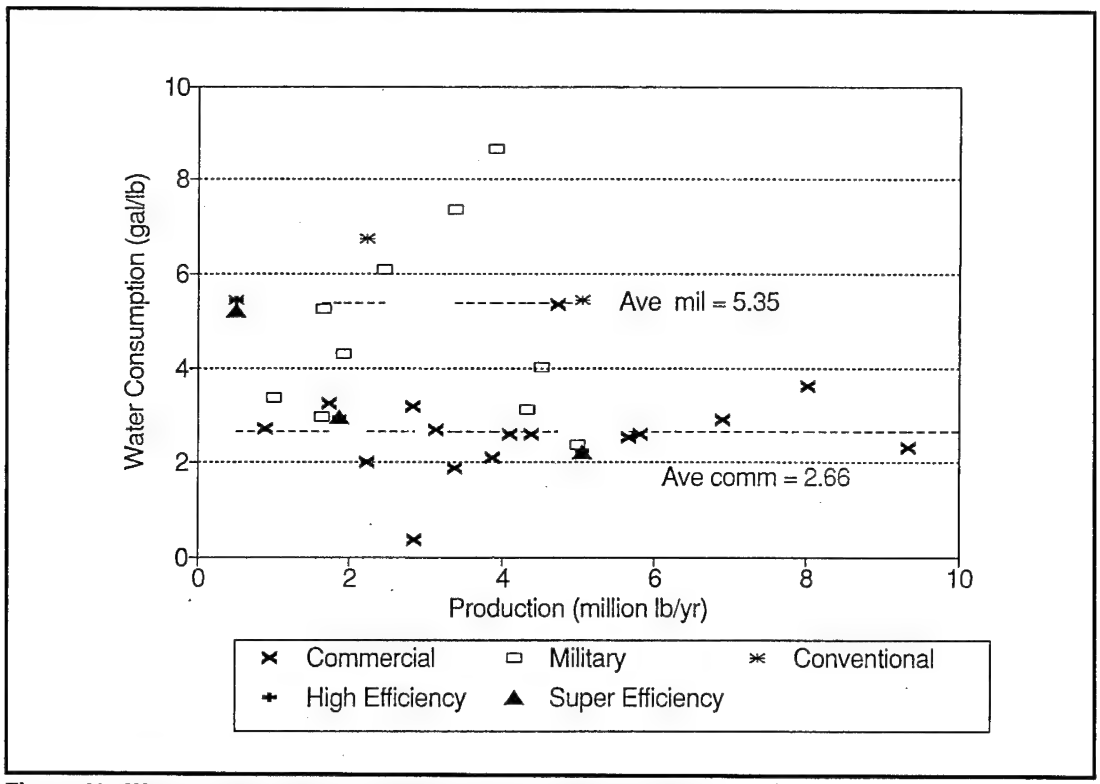


Figure 48. Water consumption comparison with model facilities.

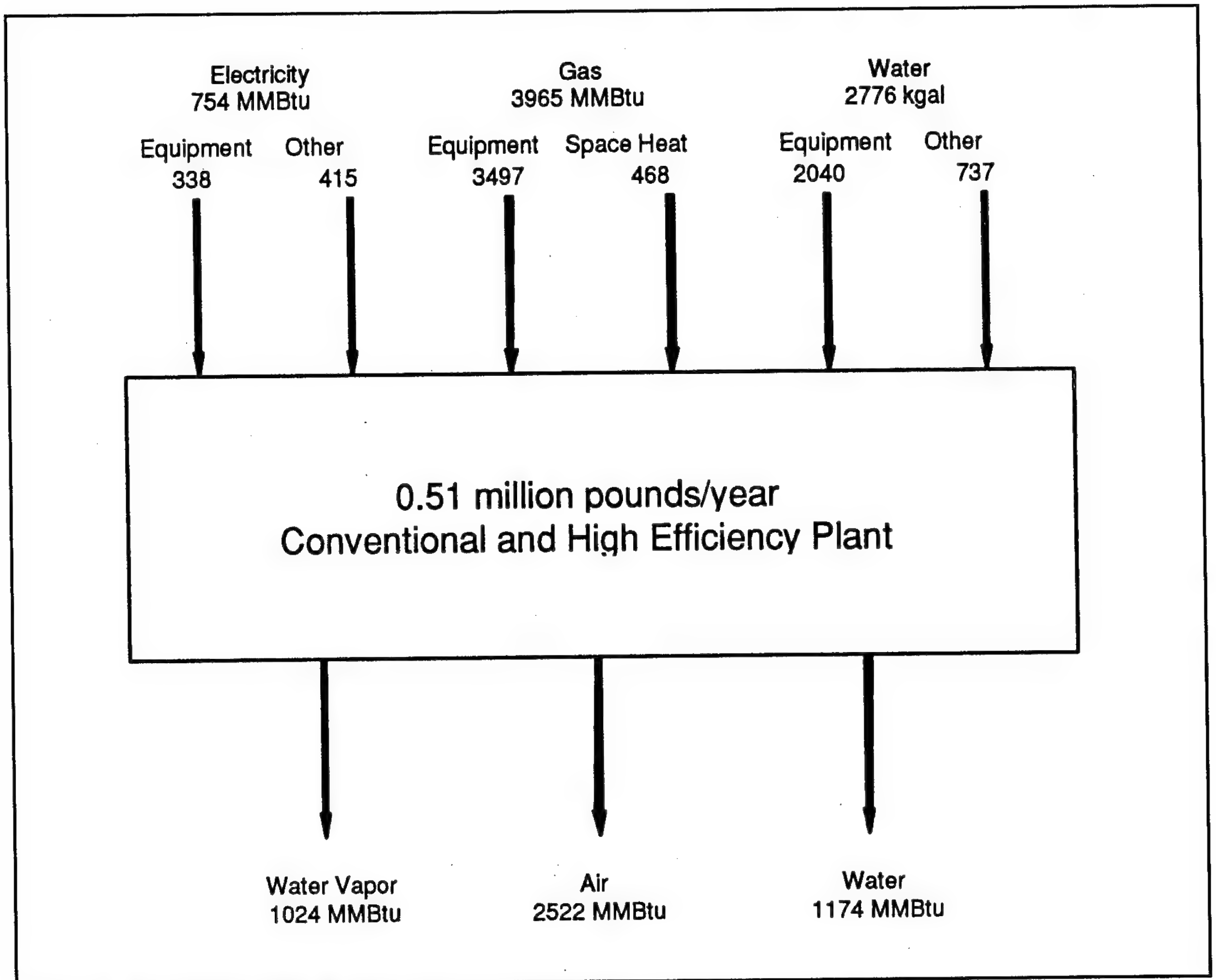
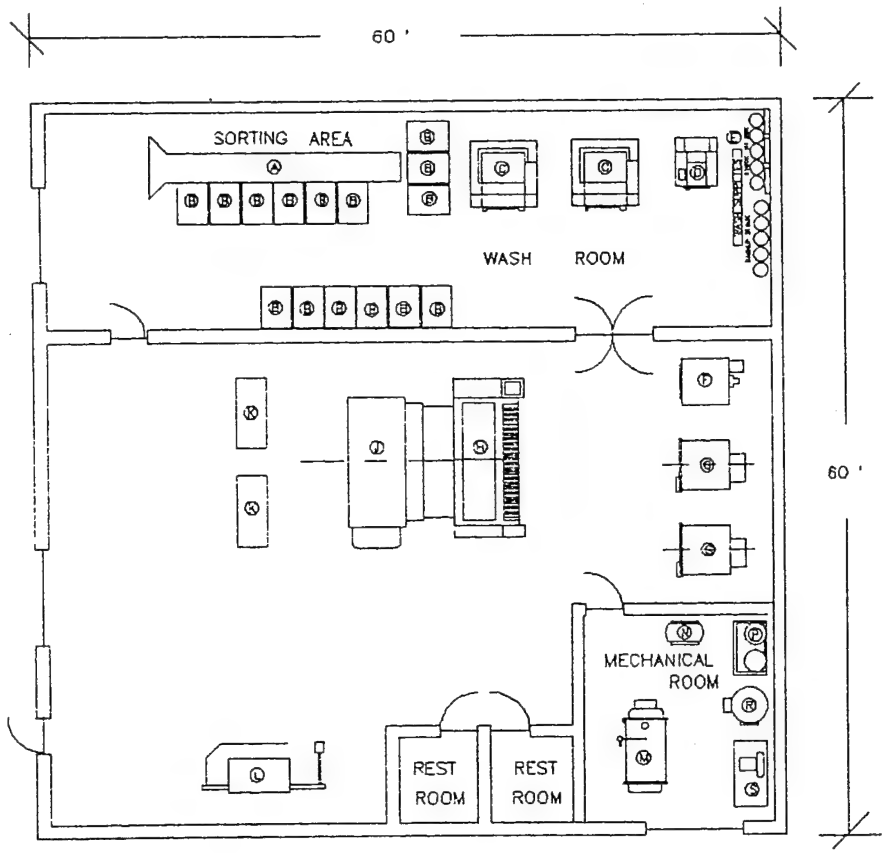


Figure 49. Energy flow diagram for small, conventional/high efficiency model facility.



EQUIPMENT LIST

A. MANUAL SORTING TABLE.
B. CART 30 X 42 X 28.
C. 125 LB. WASHER EXTRACTOR.
D. 85 LB. WASHER EXTRACTOR.
E. PERISTALTIC PUMP SUPPLY SYSTEM
F. 110 LB. GAS FIRED DRYER.
G. 150 LB. GAS FIRED DRYER.
H. SINGLE ROLL 24" IRONER.
J. DOUBLE LANE PRIMARY/CROSS FOLDER.
K. SMALL PIECE FOLDING TABLES 30" X 72".
L. STEAM AIR TUNNEL GARMENT FINISHER (250 / HR.).
M. 15 HP DUAL FIRED STEAM BOILER.
N. DEAERATOR RETURN SYSTEM.
P. WATER SOFTENER.
R. GAS FIRED HOT WATER HEATER.
S. 10 HP. AIR COMPRESSOR.
T.
U.
V.
W.
X.
Y.
Z.

Figure 50. Layout for small, conventional/high efficiency model facility.

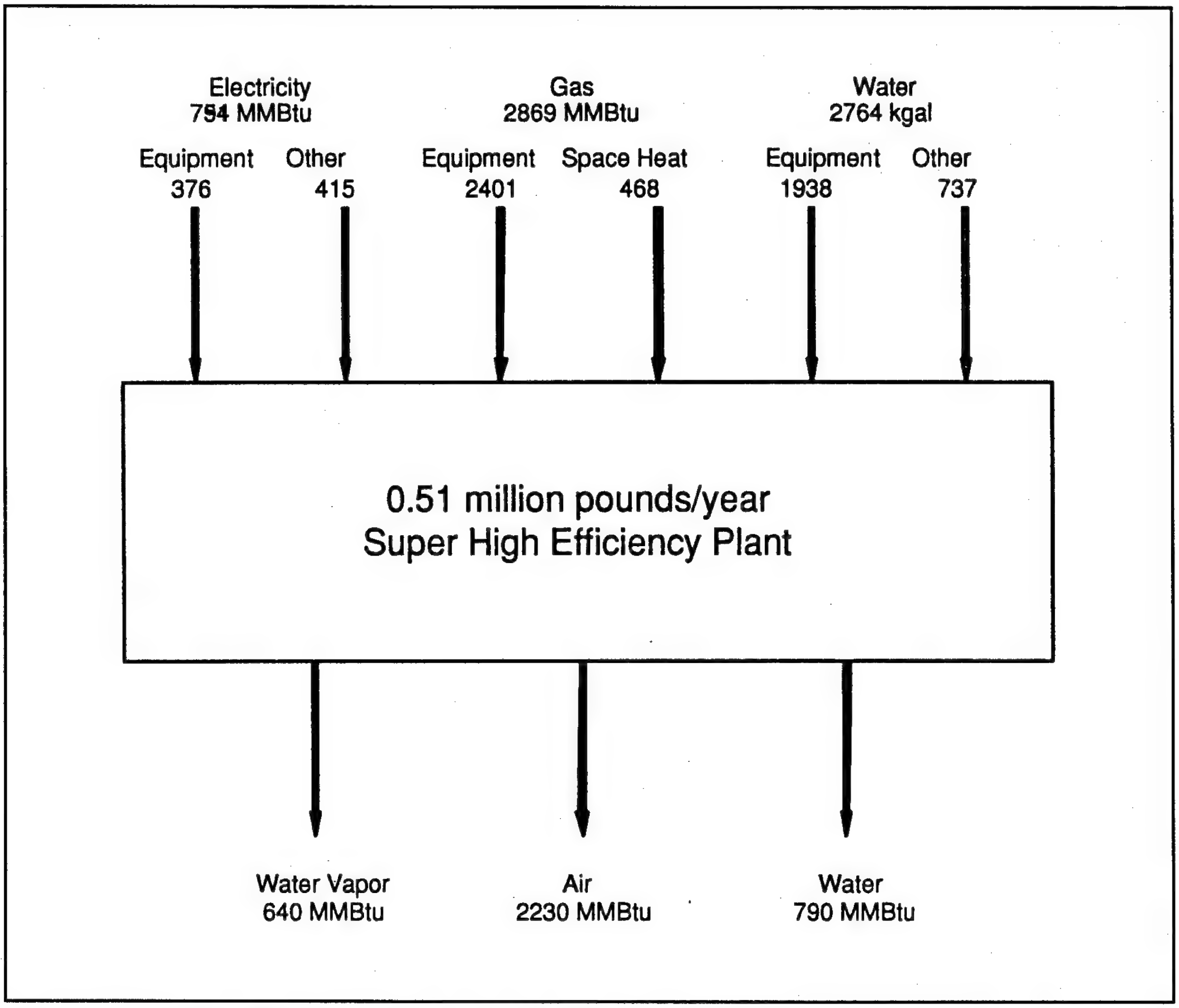


Figure 51. Energy flow diagram for small, super high-efficiency model facility.

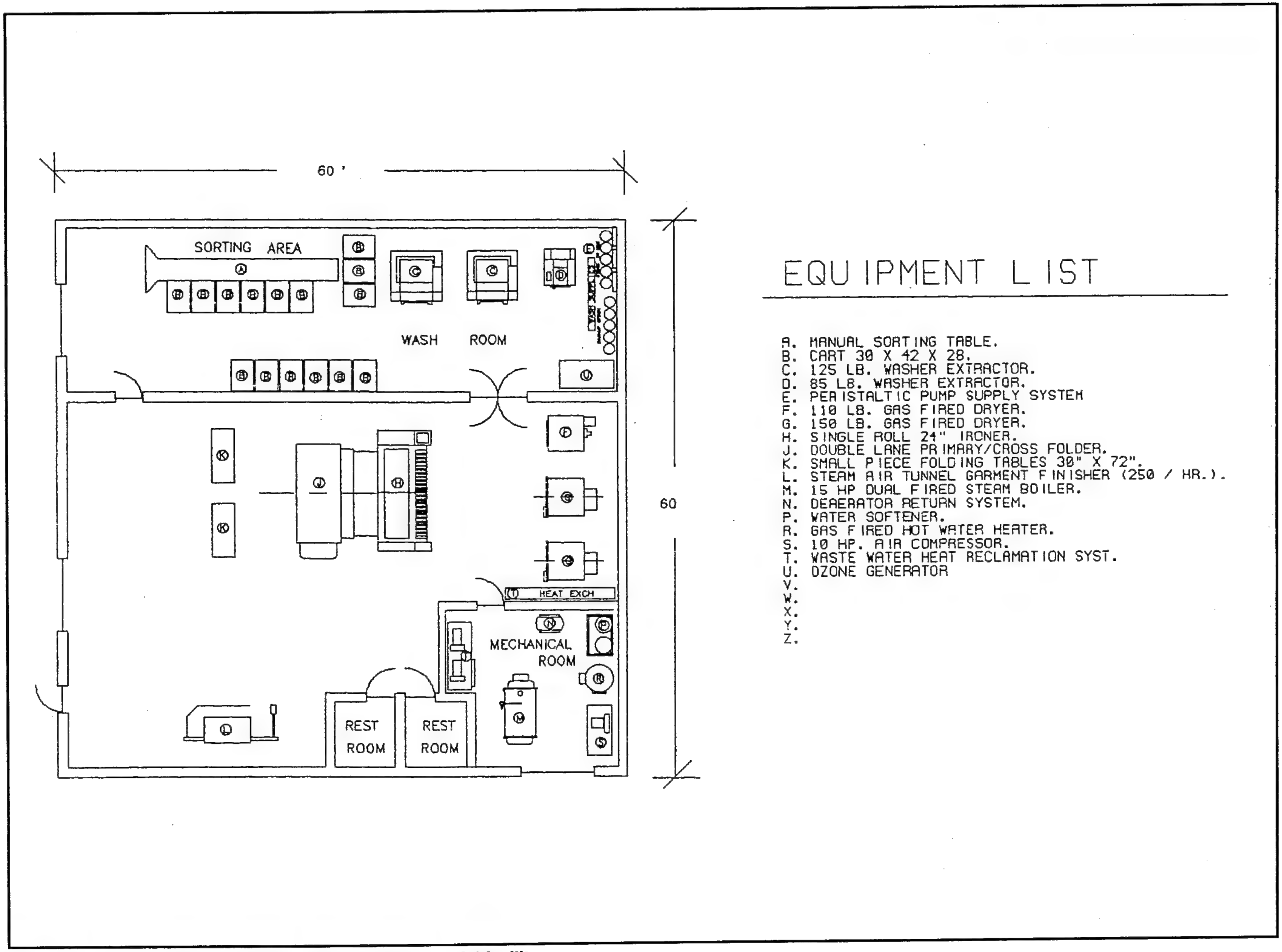


Figure 52. Layout for small, super high-efficiency model facility.

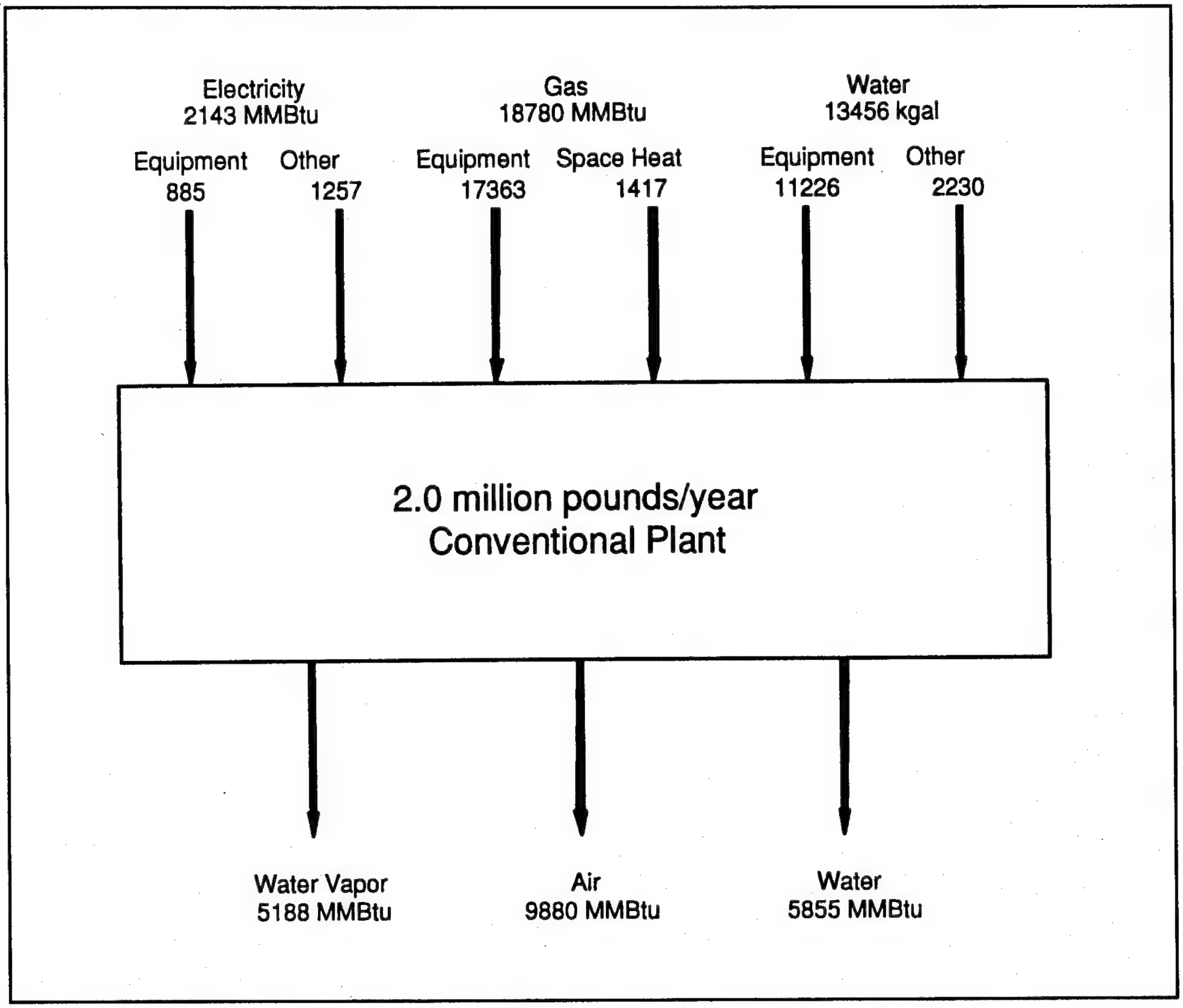


Figure 53. Energy flow diagram for medium conventional model facility.

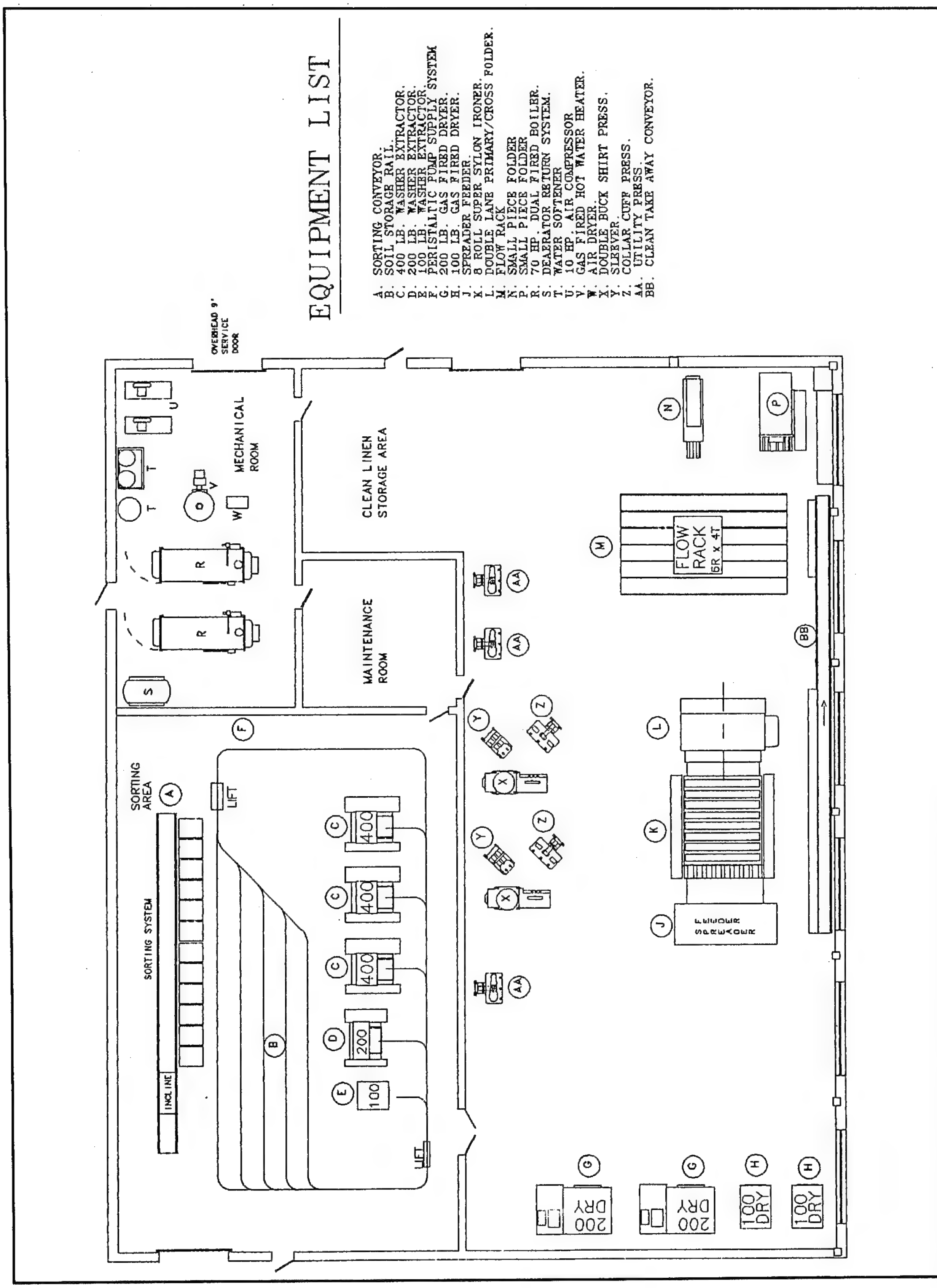


Figure 54. Layout for medium, conventional model facility.

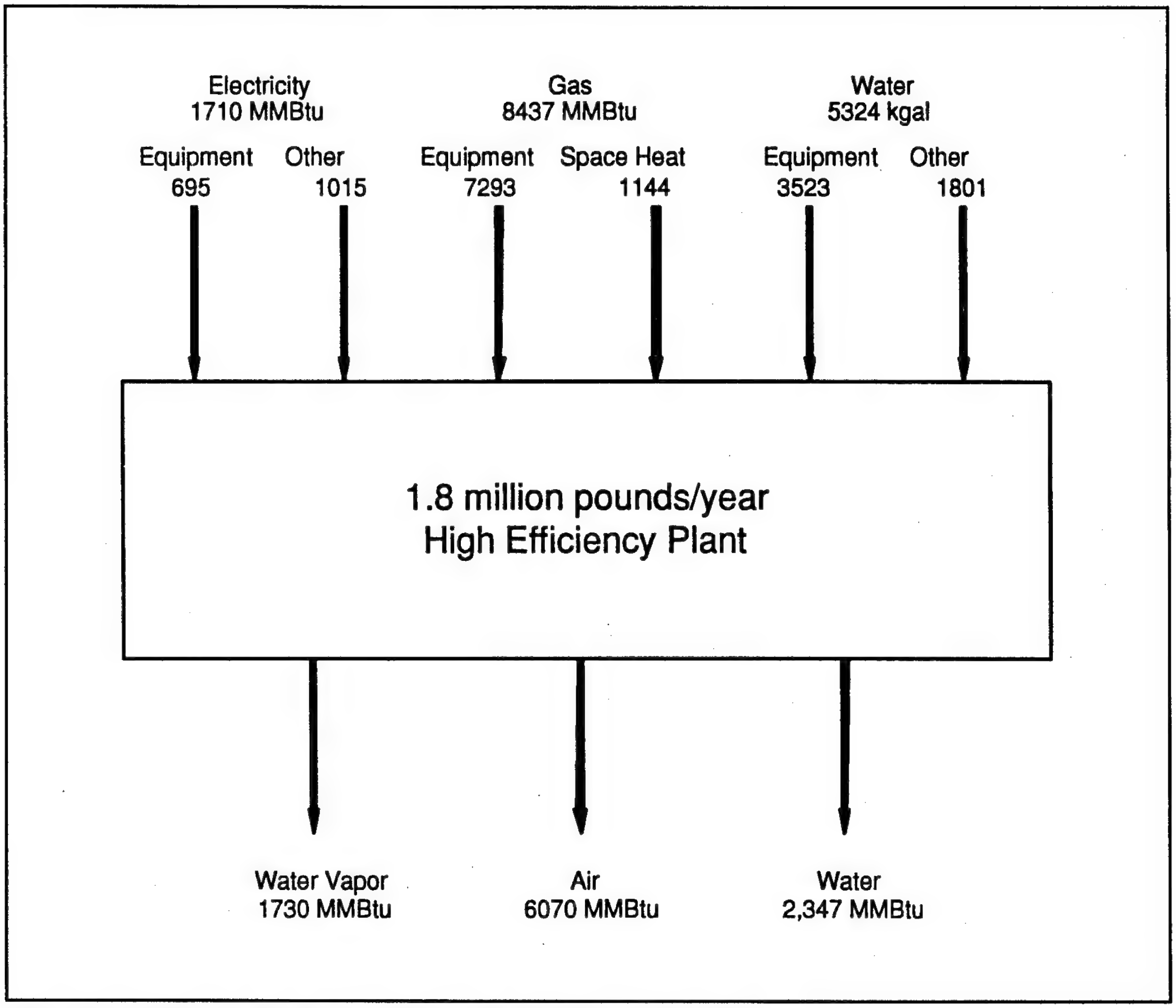


Figure 55. Energy flow diagram for medium, high-efficiency model facility.

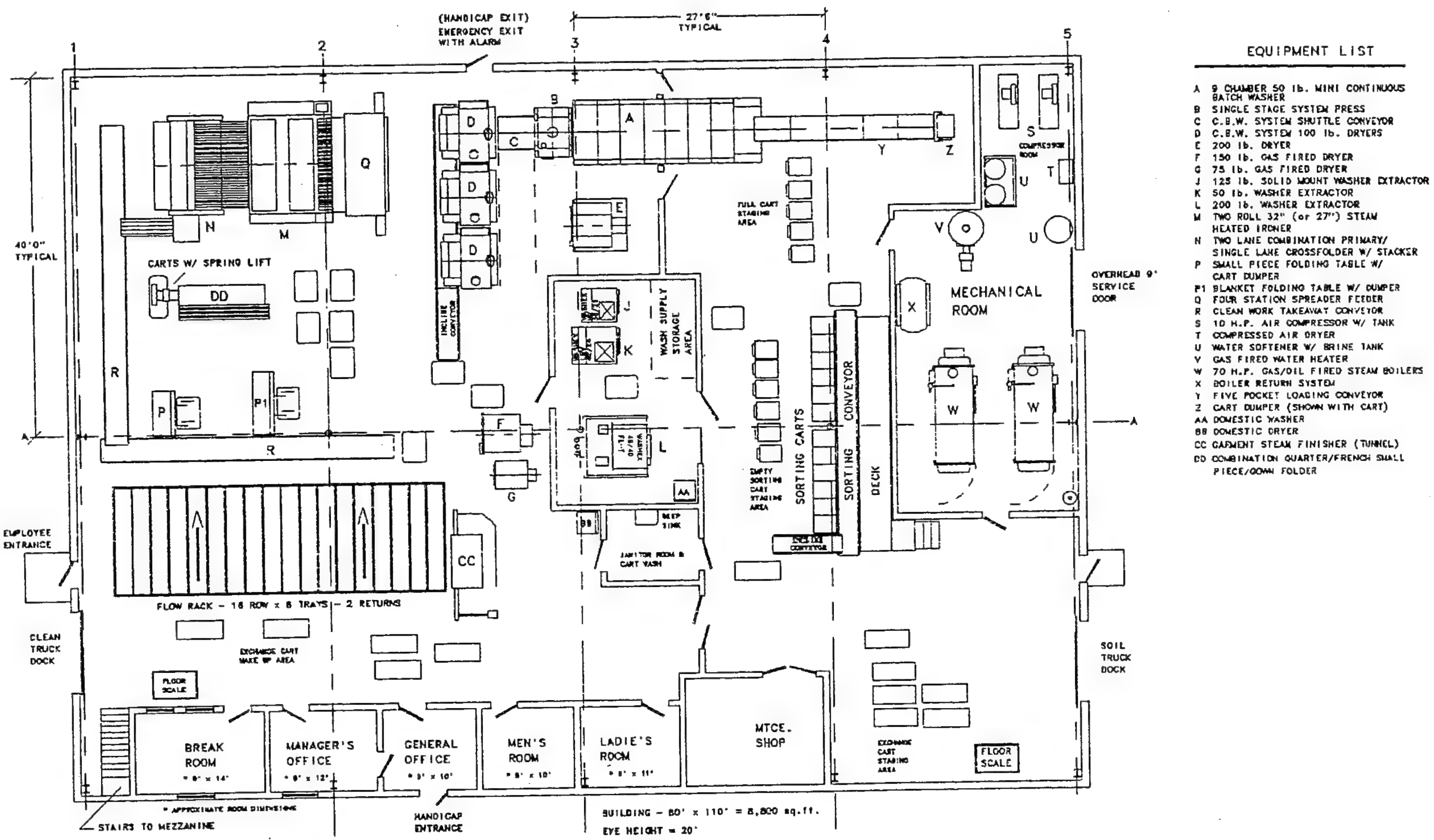


Figure 56. Layout for medium, high-efficiency model facility.

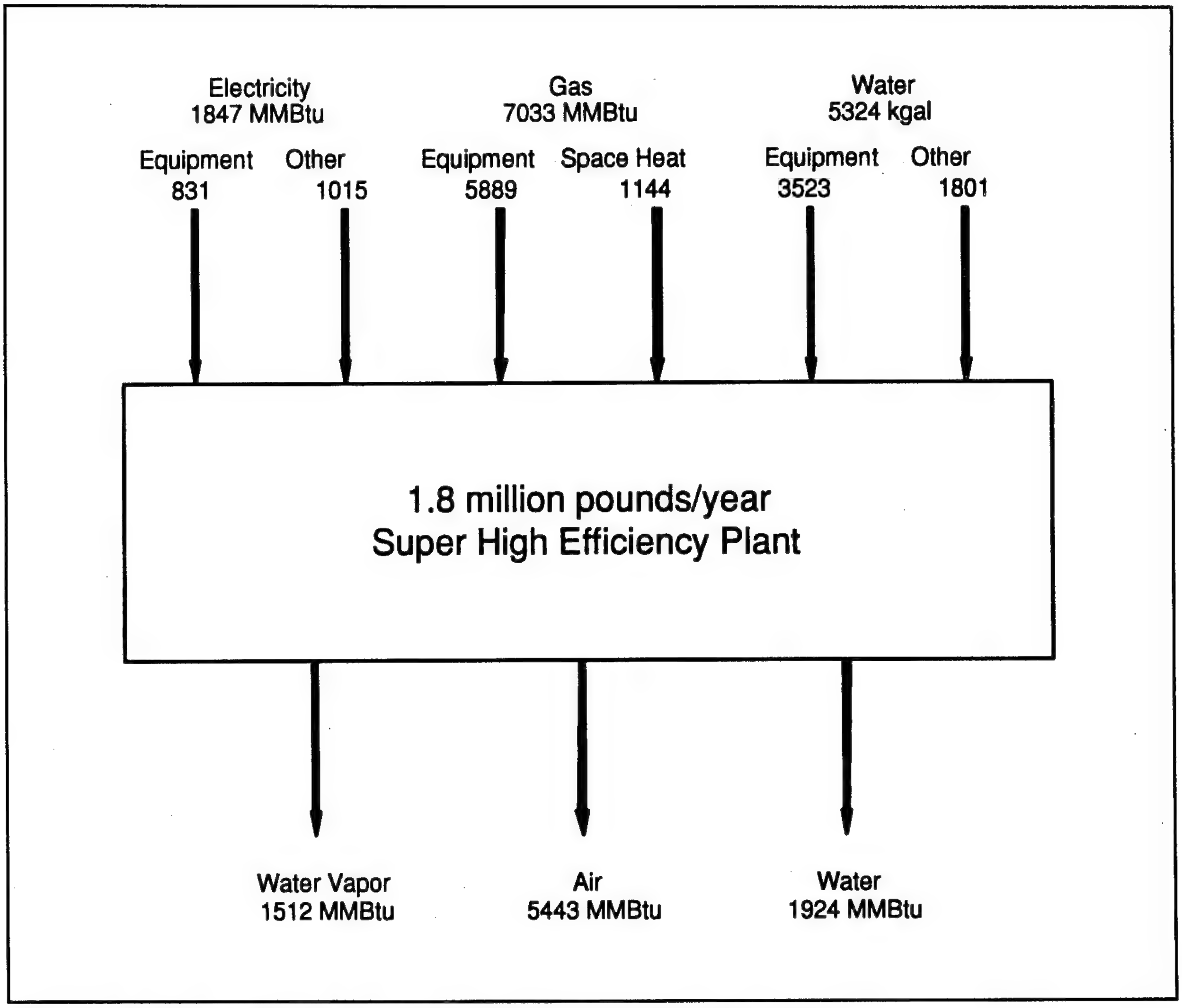


Figure 57. Energy flow diagram for medium, super high-efficiency model facility.

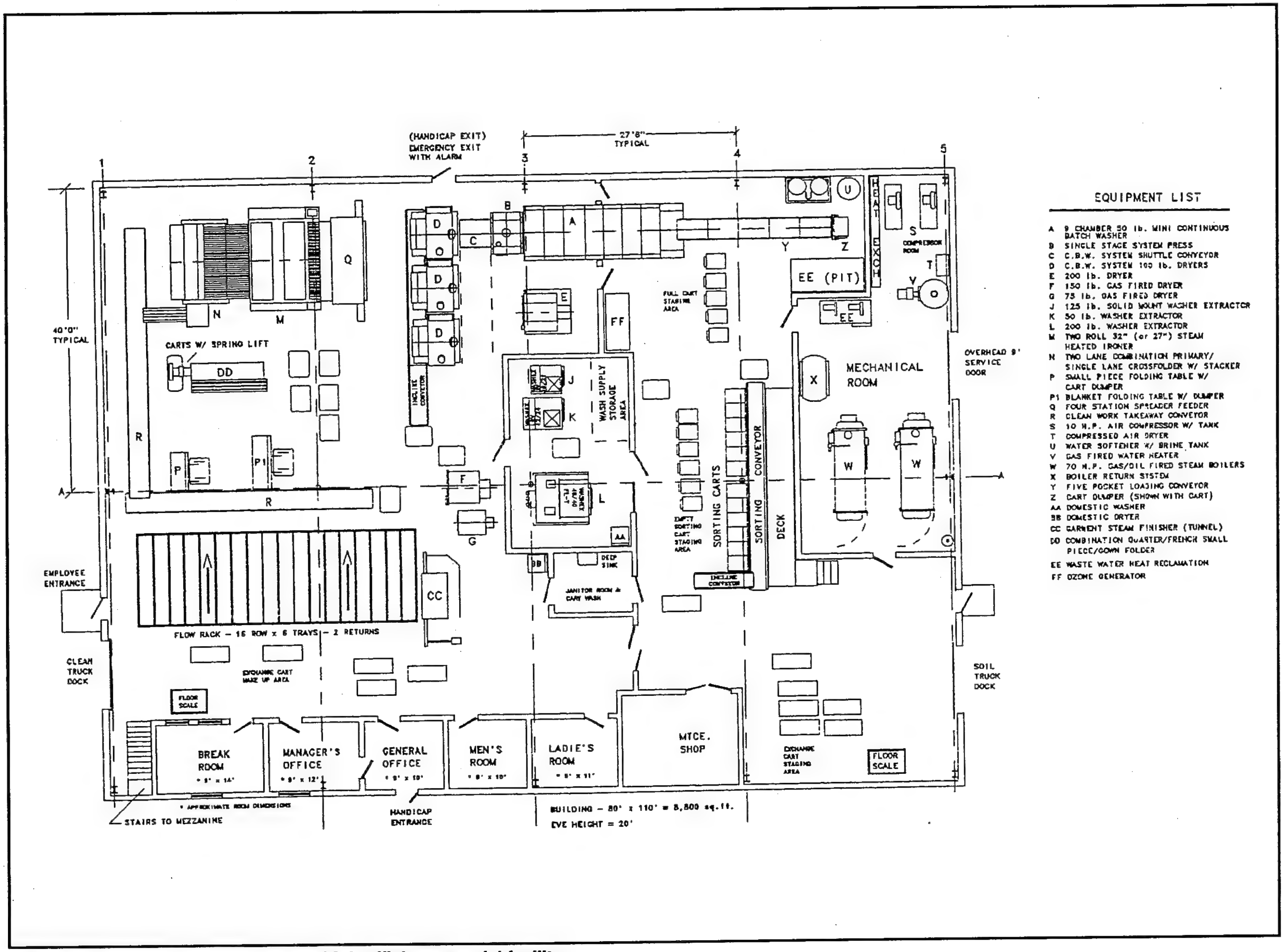


Figure 58. Layout for medium, super high-efficiency model facility.

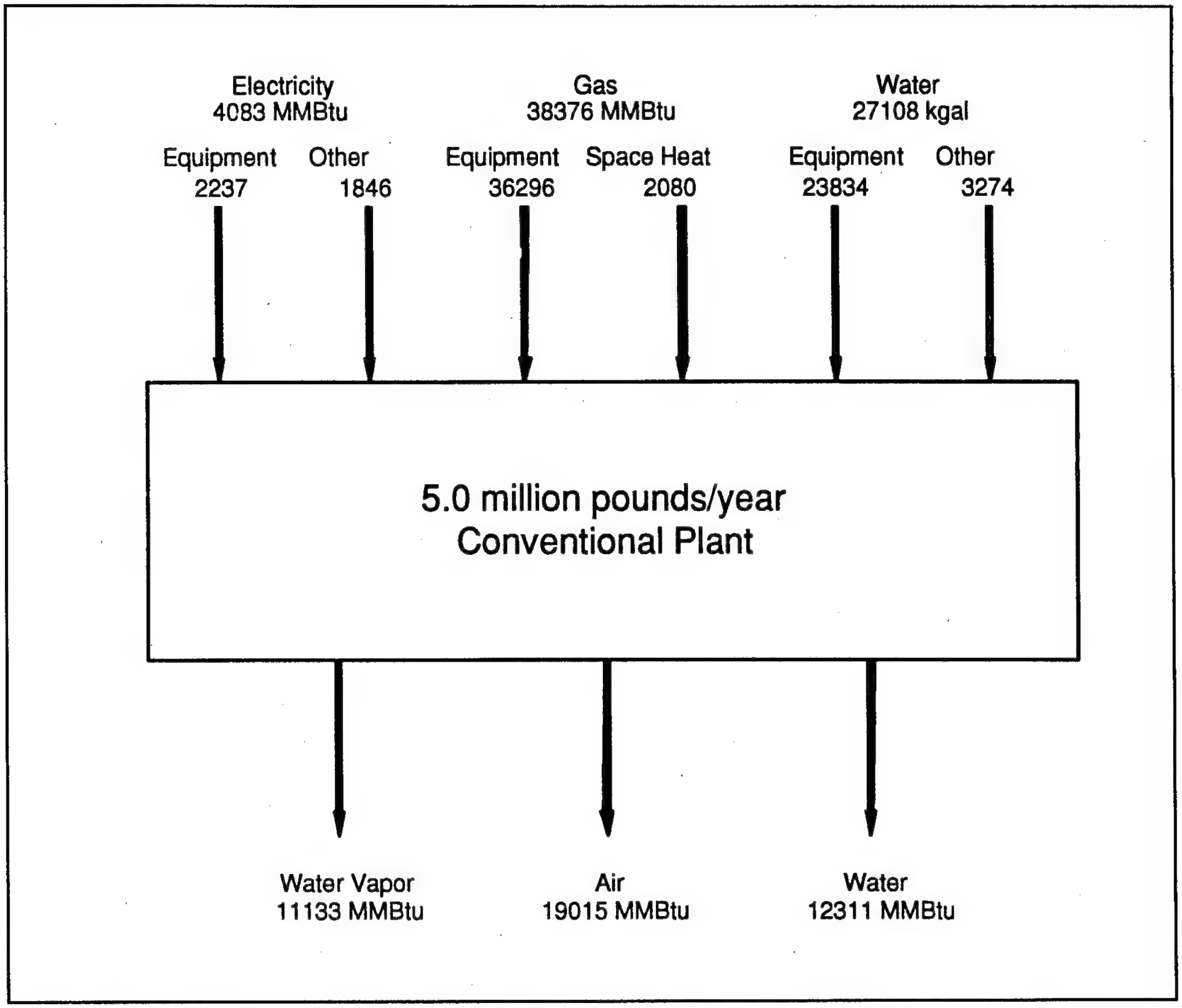


Figure 59. Energy flow diagram for large, conventional model facility.

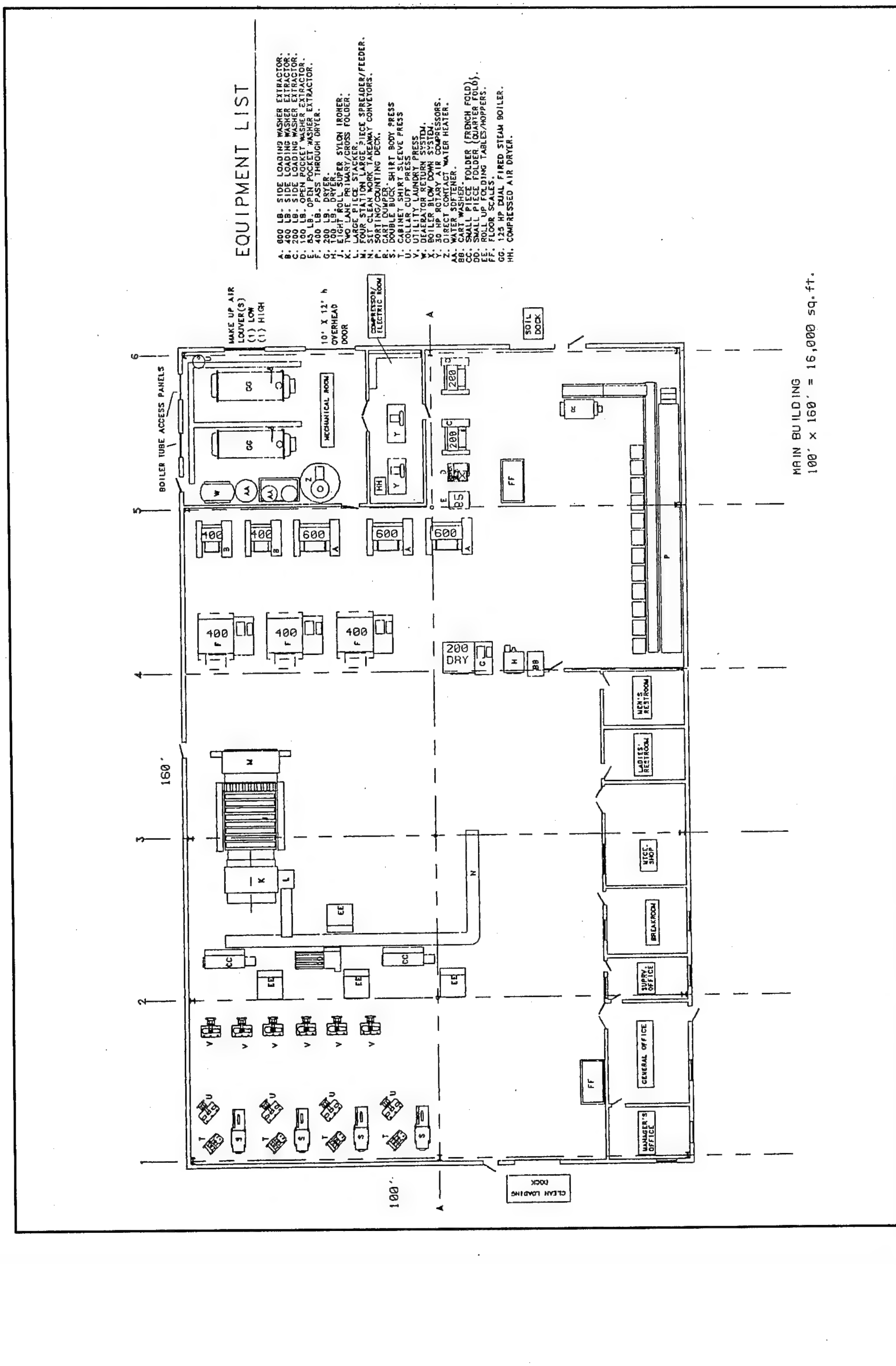


Figure 60. Layout for large, conventional model facility.

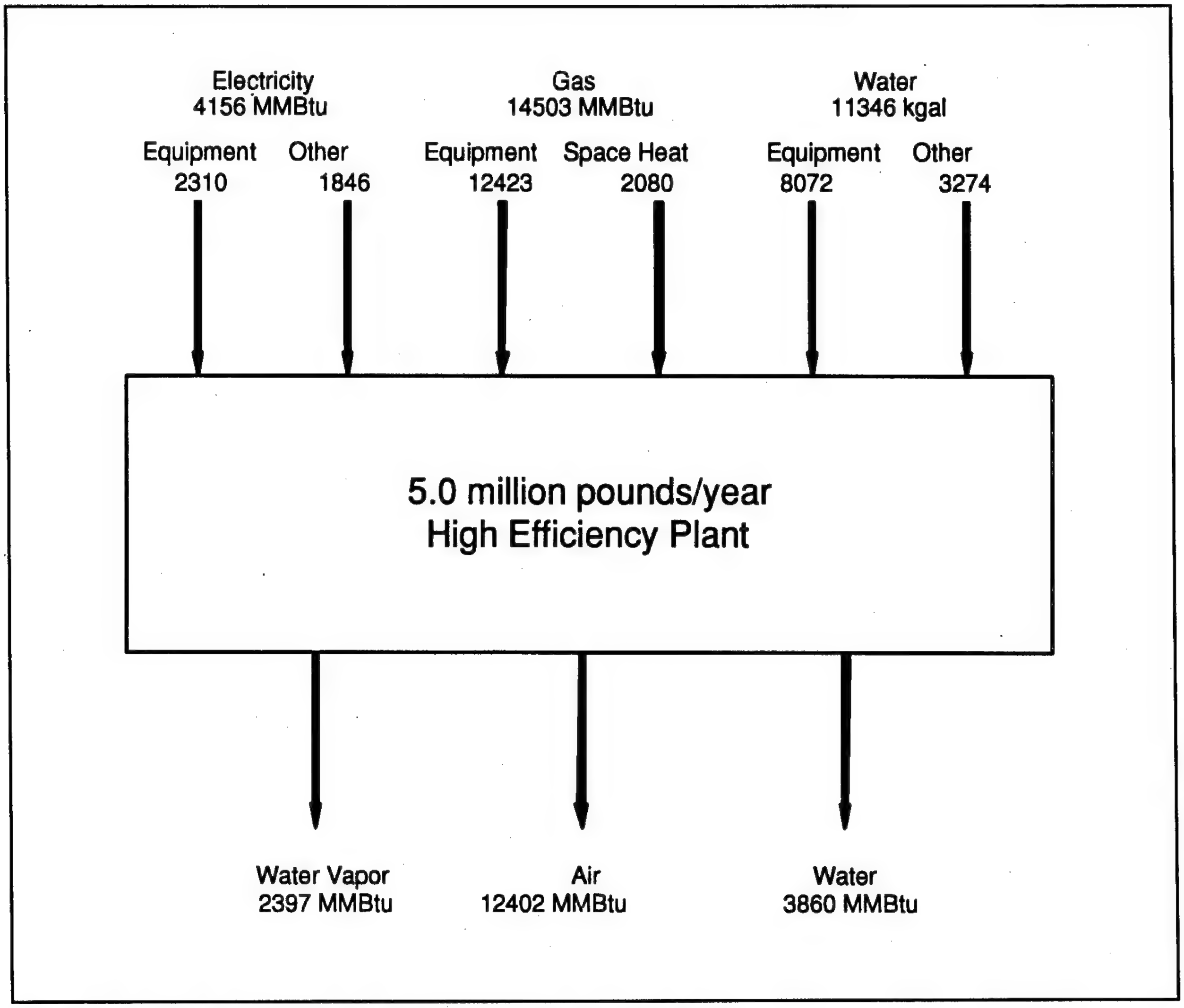


Figure 61. Energy flow diagram for large, high-efficiency model facility.

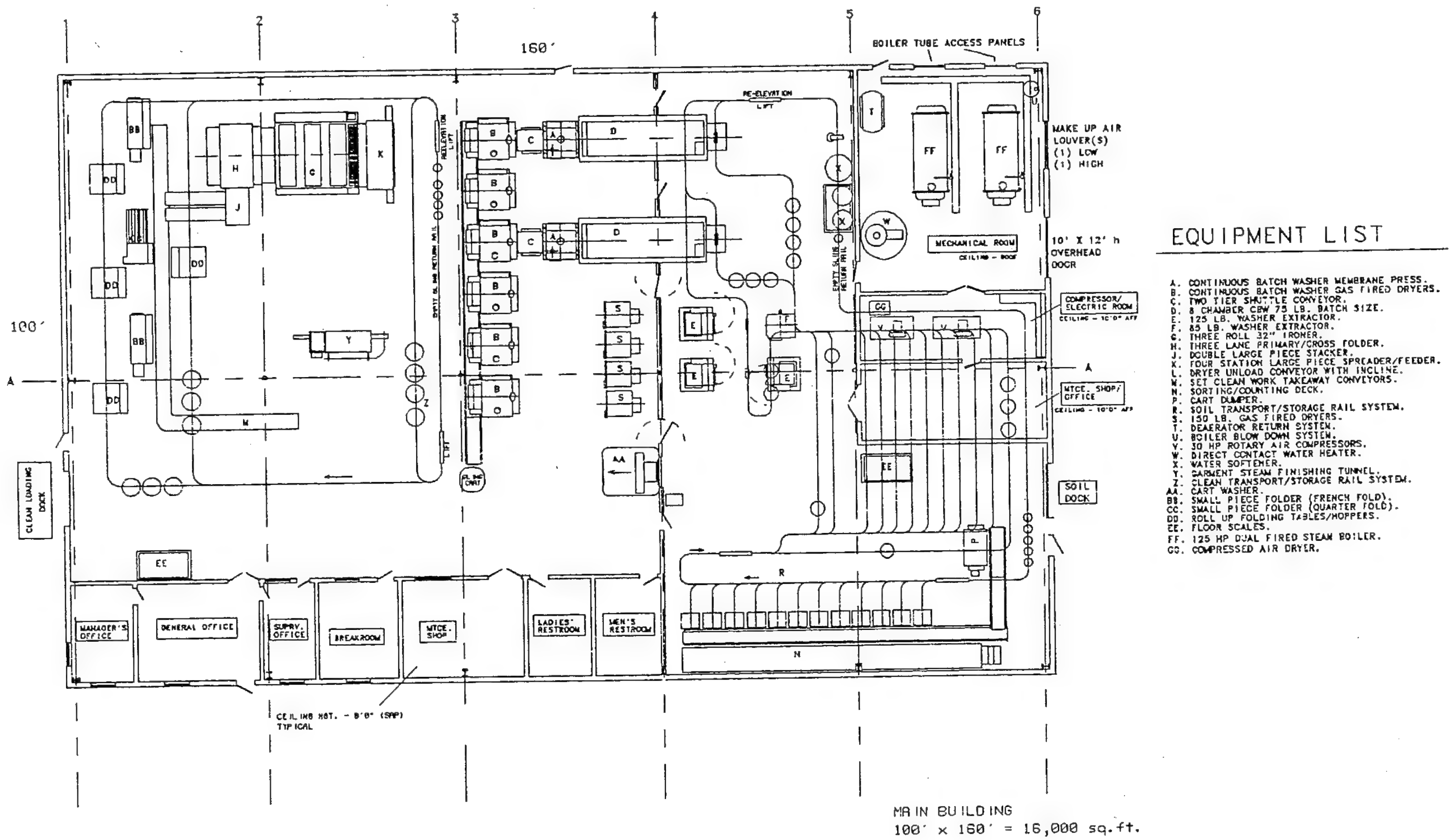


Figure 62. Layout for large, high-efficiency model facility.

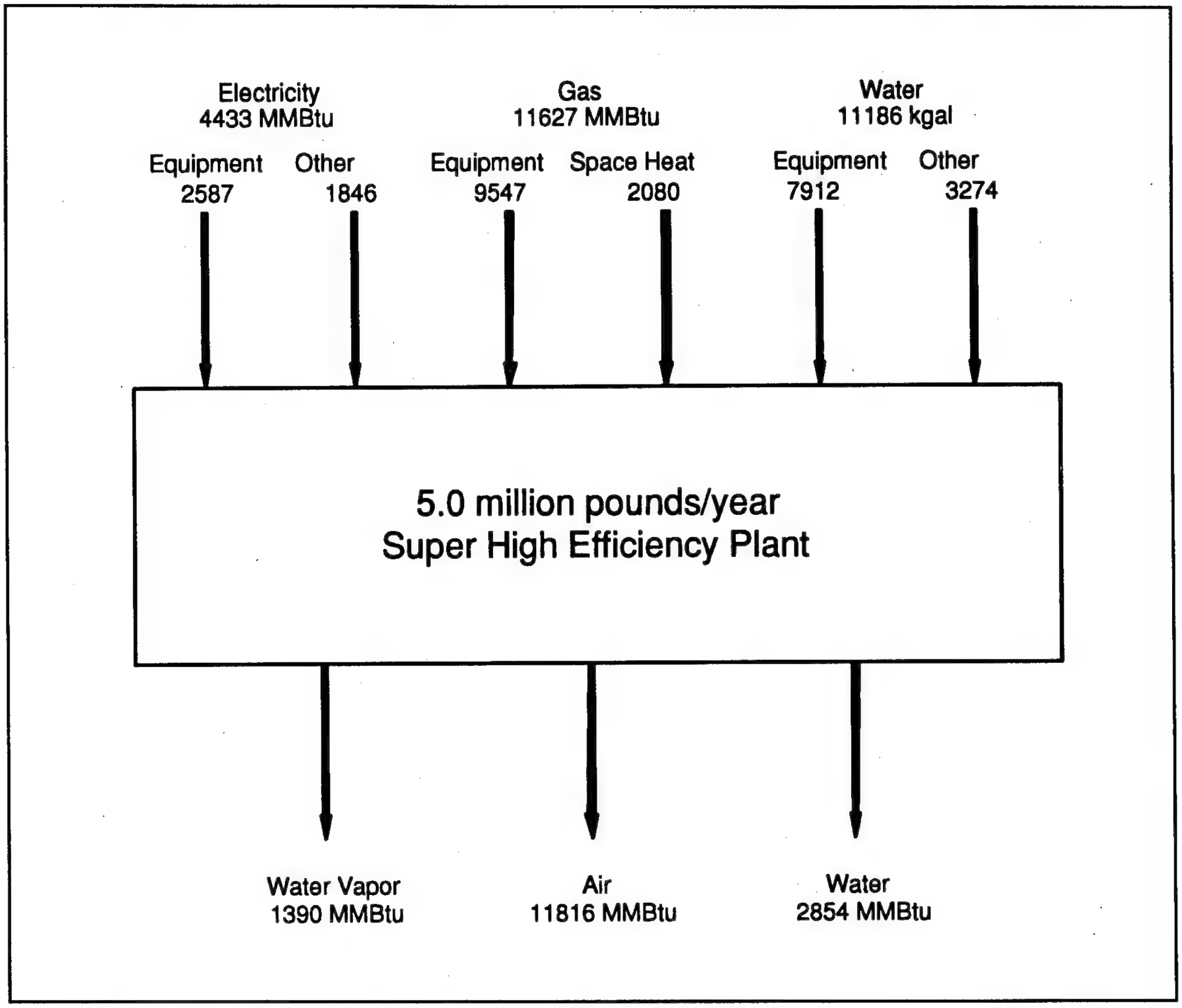


Figure 63. Energy flow diagram for large, super high-efficiency model facility.

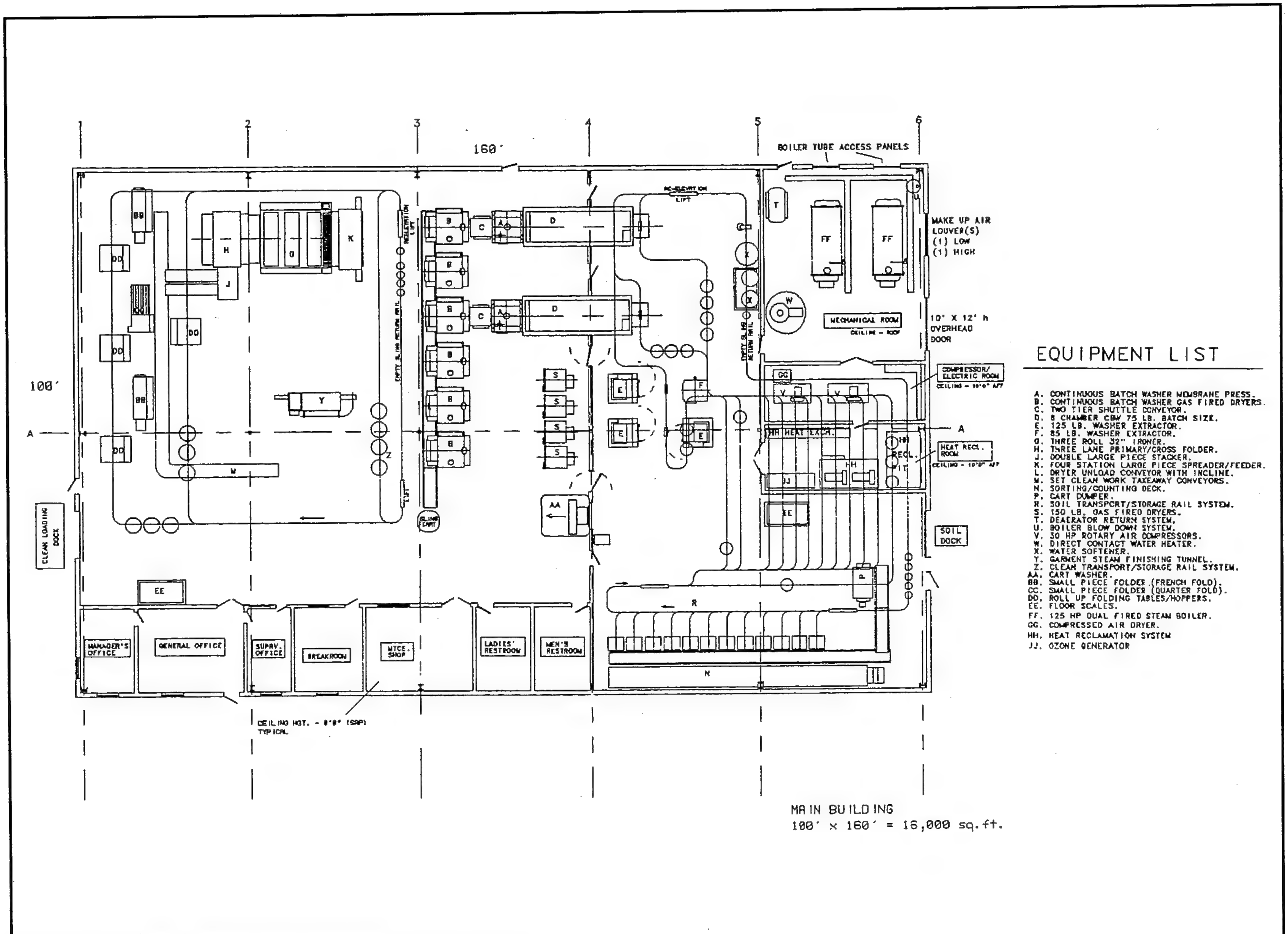


Figure 64. Layout for large, super high-efficiency model facility.

5 Conclusions and Recommendations

This study contacted personnel at 28 installations and sent surveys to determine energy use, annual production, and operating conditions at those DOD laundry facilities. Site visits were also made to several installations to visually inspect equipment and to review current operating practices. Data were entered into a spreadsheet and graphically analyzed. A preliminary data analysis revealed significant variations in the amount of energy consumed by DOD laundry facilities of comparable capacities. It was concluded that the scattering of data points may have resulted from any one or combination of several causes:

- inefficient equipment operation
- equipment in need of tuning or repair
- use of outdated equipment
- faulty utility-metering equipment
- lack of metering equipment.

Currently, utility consumption at DOD laundry facilities may not be monitored by personnel at the laundry site and is sometimes billed according to outdated formulas that assign an arbitrary percentage of installation-wide utility use to the laundry. Such outmoded billing formulas and spotty metering may inadvertently result in overspending on utilities. It is difficult to demonstrate or verify the effectiveness of conservation measures without past performance data for comparisons. It is therefore recommended that utility consumption in DOD laundries be accurately metered; this would greatly enhance the ability of managers to implement conservation methods.

When compared to the DOD laundry data, data on commercial laundry facilities showed that, on average, the military facilities studied used approximately 12 percent less electricity and 129 percent more thermal energy per pound of processed laundry than comparable commercial facilities. This apparent advantage in electricity savings is offset by the fact that electricity consumption typically ranges only from 9 to 15 percent of total energy consumption in commercial laundries. Average water consumption in the military laundries studied was 40 percent higher than that of the commercial laundries studied. Military laundries typically employed 12.70 people per million pounds of laundry processed as opposed to only 7.71 people per million pounds of laundry processed in commercial facilities.

Model laundry facilities were developed to be similar in capacity and function to DOD laundries, and were compared to both military and commercial laundry plants. The models for each of the three common size ranges included one model using standard equipment and two using state-of-the-art equipment and technologies to project optimal utility efficiencies. The models also indicate that commercial laundries appear to be operating more efficiently in terms of utility consumption than many DOD laundries.

Old equipment, such as has become common in DOD laundry facilities due to tight military budgets, is generally less efficient than newer equipment that employs recent technologies, and more difficult to repair due to scarcity of parts and lack of manufacturer support. At least in terms of its laundry facilities, the reduction in operations and maintenance funding has taken a toll on the DOD infrastructure.

This study concludes that the efficiency of DOD laundry facilities may be greatly improved by implementing modern energy management techniques, by obtaining new equipment, and by providing additional personnel training. It is recommended that DOD implement advanced water and energy conservation/recycling technologies as outlined in the alternative facility designs modeled in this study to allow its laundry facilities to become competitive with commercial laundries of similar production capacity. Modernization efforts can greatly enhance DOD facilities' ability to provide competitive, high-quality services to military personnel. It is therefore also recommended that individual installations should do appropriate cost analyses to determine whether laundry plant energy improvements qualify for funding assistance under ECIP. Since similar government-owned, government-operated facilities (belonging to the Veterans' Administration) are consistently competitive with commercial laundries, it is clearly in the best interest of the government to own and operate its own laundry facilities.

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"Getting the Most for Your Energy Dollar," *Special Reporter*, vol 20, No. 2 (International Fabricare Institute, Silver Spring, MD, March 1992).

Appendix A: DOD Laundry Survey

DOD LAUNDRY PLANT ENERGY EFFICIENCY STUDY

ENERGY USE SURVEY

CONTROL NUMBER ______

IDENTIFICATION INFORMATION

INSTALLATION	____________	DATE	________
POC	____________	POC PHONE #	________
OFFICE SYMBOL	____________	COMMAND	________
ADDRESS	____________	DOD BRANCH	________
CITY	____________	LAUNDRY BLDG #	________
ZIP	____________	TYPE OF LAUNDRY	________

COMMENTS

____

____

____

____

____

CONTROL NUMBER ________

PRODUCTION INFORMATION

ANNUAL PRODUCTION (1 lb = 1 piece)	
COMMERCIAL/FAMILY	________
HEALTHCARE	________
LINEN	________
RENTAL (UNIFORM)	________
OTHER	________
TOTAL	________

TYPICAL OPERATION	
# DAYS/WEEK	________
# HOURS/DAY	________
# EMPLOYEES	________
PLANT OUTPUT	(lbs/day) or (per day)
DAILY AVE	________
MAX CAPACITY	________

ANNUAL OPERATING COSTS

UTILITIES	USE	$/UNIT	COST
ELECTRICITY (kWh)	________	____	________
NATURAL GAS (MCF)	________	____	________
OIL (#__) (Kgal)	________	____	________
DOMESTIC H_2O (Kgal)	________	____	________
HOT H_2O (Kgal)	________	____	________
STEAM (Klbs)	________	____	________
OTHER (Sewer)	________	____	________

ANNUAL COSTS	
ENERGY	____
LABOR	____
SUPPLIES	____
OVERHEAD	____
OTHER	____
COST/lb	____

ENERGY CONSUMING EQUIPMENT: WASHERS, DRYERS, IRONERS, PRESSES, ETC.

EQUIPMENT DESCRIPTION	# OF UNITS	CAPACITY	ENERGY SOURCE	PEAK DEMAND (amps, Btu/hr)	OPERATING psi	OPERATING oF	YEAR INST	** STATUS
________	____	________	________	________	____	____	____	____
________	____	________	________	________	____	____	____	____
________	____	________	________	________	____	____	____	____
________	____	________	________	________	____	____	____	____
________	____	________	________	________	____	____	____	____
________	____	________	________	________	____	____	____	____
________	____	________	________	________	____	____	____	____
________	____	________	________	________	____	____	____	____

STATUS 1-NORMALLY ON
2-HOT STANDBY
3-COLD STANDBY
4-OUT OF ORDER

CONTROL NUMBER ________

ENERGY CONSERVATION FOR LAUNDRY

	YES	NO
MICROPROCESSOR CONTROLS ON LAUNDERING EQUIPMENT	___	___
FULLY AUTOMATED (HANDS-0FF) WASHROOM	___	___
RECOVER HEAT FROM DRYER EXHAUSTS	___	___
PREVENTATIVE MAINTENANCE SCHEDULE	___	___
ISOLATION VALVES FOR IDLE EQUIPMENT	___	___
CONTINUOUS BATCH WASHERS	___	___
OZONATION SYSTEMS	___	___
THERMAL FLUIDS	___	___
DIRECT FIRED H_2O HEATER	___	___
WASTEWATER HEAT RECLAIMER	___	___
(IF YES, EXPLAIN-TEMPERED H_2O)	________	
OTHER ENERGY CONSERVATION METHODS USED	________	
OTHER NEW TECHNOLOGIES USED	________	

PLANT BOILER DATA

	BLR #	CAPACITY	FUEL TYPE	OPERATING psi	OPERATING oF	DIST. MEDIA (Hot water; Steam)	YEAR INST	** STATUS
BOILER	___	______	___	___	___	___	___	___
BOILER	___	______	___	___	___	___	___	___
BOILER	___	______	___	___	___	___	___	___
BOILER	___	______	___	___	___	___	___	___

OPERATOR: 1. 24 HOURS 2. LAUNDRY TIME 3. ROVING 4. ON CALL

ENERGY CONSERVATION FOR BOILER ROOM

	YES	NO
BOILER CONTROLS WORKING PROPERLY	___	___
STACK TEMPERATURE MEASURED	___	___
CO_2, CO, O_2, NO_X ANALYZED	___	___
PROPER BLOWDOWN OF BOILERS	___	___
DAMPER CONTROLS WORKING PROPERLY	___	___
CONDENSATE RETURN SYSTEM	___	___
(IF YES, % RETURNED___)		
TRAPS WORKING PROPERLY	___	___
HOT WATER TANKS ARE SIZED ADEQUATELY	___	___
BOILER WATER IS CHEMICALLY TREATED	___	___
FUEL METERED	___	___
ELECTRICITY METERED	___	___
WATER METERED	___	___
STEAM METERED	___	___
CONDENSATE RETURN RECOVERY TANK SIZED ADEQUATELY	___	___
BANK/TURNDOWN @ OFF HOURS	___	___
CHAIN VALVES FOR MAIN HEADERS	___	___

TYPE OF TRAPS ________

Appendix B: Summary of Commercial and Military Laundry Data

Table B1. Commercial laundry energy data.

Plant	Production (Mlb/yr)	Annual Energy Use							Normalized		Annual Energy Cost ($)				
		Electric (kWh)	Natl Gas (kcf)	Oil (kgal)	Steam (klb)	Non-Elec (MBtu)	Electric (MBtu)	Total (MBtu)	Electric (kWh/lb)	Non-Elec (kBtu/lb)	Electric	Natl Gas	Oil	Steam	Total
DGA	0.883650	583,040	10,708			10,708	1,990	12,698	0.660	12.118	53,406	58,319			111,725
RNM	1.715250	264,120	7,538	4.635		8,210	901	9,112	0.154	4.787	20,717	23,016	5,298		49,031
POR	1.860227	333,800	7,693			7,693	1,139	8,832	0.179	4.136	19,093	25,067			44,160
SUT	2.220400										27,094	31,126			58,220
SCA	2.833814										45,843	40,860			86,703
SIN	2.842447	387,420	8,945			8,945	1,322	10,267	0.136	3.147	19,372	33,265			52,637
CNE	2.940979	119,160	10,269			10,269	407	10,675	0.041	3.492	7,149	48,263			55,412
DCO	3.131316										23,176	44,094			67,270
BCT	3.380010	869,400	16,245			16,245	2,967	19,212	0.257	4.806	85,326	67,573			152,899
BND	3.870000	389,000	7,766			7,766	1,328	9,094	0.101	2.007	30,315	27,431			57,746
BMA	4.107535	645,820	15,513			15,513	2,204	17,717	0.157	3.777	73,551	79,852			153,403
INJ	4.386000	576,480	11,728			11,728	1,968	13,696	0.131	2.674	67,168	55,980			123,148
GMI	4.724900	562,880	21,920			21,920	1,921	23,841	0.119	4.639	50,643	62,355			112,998
DIA	5.050000	601,440	19,105			19,105	2,053	21,158	0.119	3.783	33,095	64,637			97,732
FTX	5.668000	700,060	17,801			17,801	2,389	20,190	0.124	3.141	52,983	80,089			133,072
SNY	5.799729	897,488	18,515			18,515	3,063	21,578	0.155	3.192	105,316	38,692			144,008
LLA	6.904193	710,550	11,985			11,985	2,425	14,410	0.103	1.736	47,631	46,266			93,897
CIL	8.030144	1,351,955	44,764			44,764	4,614	49,378	0.168	5.574	130,934	158,992			289,926
HKY	9.358425	990,600	32,527			32,527	3,381	35,908	0.106	3.476	30,263	109,725			139,988
WWI	10.839671	970,480	32,128			32,128	3,312	35,440	0.090	2.964	75,874	105,923			181,797
COH	11.854879	1,279,936	33,490			33,490	4,368	37,858	0.108	2.825	89,771	108,429			198,200
GNC	20.765405	1,882,684	54,576			54,576	6,426	61,002	0.091	2.628	127,338	147,634			274,972

Table B2. Commercial laundry nonenergy data.

Plant	Production (Mlb/yr)	Annual Water Use (kgal)	Annual Water Normalized (gal/lb)	Cost ($)	Annual Sewer Use (kgal)	Annual Sewer Cost ($)	Operating Cost ($/lb)	Personnel Number	Personnel Normalized (num/Mlb)	Age (yrs) <2	Age (yrs) 2-5	Age (yrs) 5-10	Age (yrs) 10-20
DGA	0.883650	11,093	12.554	10,862		17,249		35	39.6		x		
RNM	1.715250	4,633	2.701					25	14.6				x
POR	1.860227	6,051	3.253	5,915		9,352		17	9.1	x			
SUT	2.220400							12	5.4				x
SCA	2.833814	5,729	2.022	8,526		14,198		19	6.7			x	
SIN	2.842447	9,058	3.187			20,400		20	7.0			x	
CNE	2.940979	1,062	0.361	319		1,169		22	7.5				x
DCO	3.131316			4,235		11,473		31	9.9			x	
BCT	3.380010	9,075	2.685	18,985				25	7.4			x	
BND	3.870000	7,294	1.885	11,502		7,424		22	5.7			x	
BMA	4.107535	8,655	2.107	22,504		36,353		36	8.8			x	
INJ	4.386000	11,308	2.578	32,960		9,000		55	12.5			x	
GMI	4.724900	12,338	2.611	20,422		14,705		33	7.0			x	
DIA	5.050000	26,945	5.336	25,426		22,730		50	9.9				x
FTX	5.668000					53,642		40	7.1				x
SNY	5.799729	14,714	2.537	12,827				47	8.1		x		
LLA	6.904193	17,771	2.574	14,367		11,374		49	7.1				x
CIL	8.030144	23,418	2.916	25,372		18,958		45	5.6				x
HKY	9.358425	33,839	3.616	23,263		28,716		55	5.9			x	
WWI	10.839671	25,395	2.343	21,900		33,114		61	5.6			x	
COH	11.854879	30,601	2.581	52,262		41,157		95	8.0				x
GNC	20.765405	39,378	1.896	26,738		32,044		184	8.9			x	

Table B3. Military laundry energy data.

Plant		Annual Energy Use							Normalized		Annual Energy Cost ($)				
	Production (Mlb/yr)	Electric (kWh)	Natl Gas (kcf)	Oil (kgal)	Steam (klb)	Non-Elec (MBtu)	Electric (MBtu)	Total (MBtu)	Electric (kWh/lb)	Non-Elec (kBtu/lb)	Electric	Natl Gas	Oil	Steam	Total
A															
E															
Q	0.197728														
P	0.268340	396,000			12,600	12,600	1,352	13,952	1.476	46.955	31680	32328		141750	205,758
S	0.384000										124372	28524			152,896
H	1.004805														
M	1.281383	102,640	15,479			15,479	350	15,829	0.080	12.080	6079	73303			79,383
L	1.624068														
K	1.647167	109,168	11,151			11,151	373	11,524	0.066	6.770	6168	56760			62,928
O	1.783559	145,934	3,598	0.515		3,673	498	4,171	0.082	2.059	7997	16003	408		24,408
D	1.911106	1,321,332	27,132		31,839	58,971	4,510	63,481	0.691	30.857	100322	14297		452076	566,695
B	2.440065	317,190	17,249			17,249	1,083	18,332	0.130	7.069	23686	54490			78,176
C	2.678258	957,353	20,372	27.912	28,005	52,424	3,267	55,692	0.357	19.574	29678	22727	37280	15310	104,995
J	2.716770														
G	3.055382	538,920	23,649			23,649	1,839	25,488	0.176	7.740	50200	117400			167,600
F	3.384254	131,724	27,714			27,714	450	28,164	0.039	8.189	6860	77567			84,427
T	3.900000	259,140	31	325.500		47,228	884	48,112	0.066	12.110	18140	17007	224595		259,742
I	4.320640	425,440	33,550		24,129	57,679	1,452	59,131	0.098	13.350	19551	22774		174413	216,738
N	4.522857	694,500	32,845			32,845	2,370	35,216	0.154	7.262	35285	132384			167,669
U	5.000000	246,000		40.000	16,072	21,872	840	22,712	0.049	4.374	16064			135163	151,227
R	10.227355	717,000	19,703	2.844		20,115	2,447	22,562	0.070	1.967	44329	69336	1943		115,608

Table B4. Military laundry nonenergy data.

Plant	Production (Mlb/yr)	Annual Water			Annual Sewer		Operating Cost ($/lb)	Personnel		Age (yrs)			
		Use (kgal)	Normalized (gal/lb)	Cost ($)	Use (kgal)	Cost ($)		Number	Normalized (num/Mlb)	<2	2-5	5-10	10-20
A													
E													
Q	0.197728							20	101.1				x
P	0.268340							35	130.4			x	
S	0.384000			10228									
H	1.004805							17	16.9				
M	1.281383	4312	3.365	3333	3448	2473							
L	1.624068												
K	1.647167	4889	2.968	7140			0.22	62	37.6		x		
O	1.783559	9387	5.263	2914	7509.6	4929	0.05	42	23.5				x
D	1.911106	91528	47.893	117009	73224	78558		22	11.5				
B	2.440065	10476	4.293	18169	8376	4821		91	37.3				x
C	2.678258	16315.7	6.092				0.39	45	16.8				
J	2.716770							28	10.3				x
G	3.055382			7200				27	8.8				x
F	3.384254						0.245	31	9.2			x	
T	3.900000	28714	7.363	78676	28714	110262		30	7.7				
I	4.320640	37339	8.642	37092	29871.2	7635	0.43	63	14.6				
N	4.522857	14091.42	3.116	7232	12682.28	17706		35	7.7				
U	5.000000	20080	4.016				0.345	65	13.0			x	
R	10.227355	24480	2.394	16646				124	12.1				x

Appendix C: Commercial Laundry Data Collection Summary and Survey Form

Contacts with Local Laundering Facilities:

Fairfax Hospital

Energy use for the hospital is not separately metered. Visitors are not allowed into the laundry facility to avoid possible exposure to infectious organisms.

Shady Grove Hospital

Calls were unsuccessful in making contact with the appropriate person.

Virginia Linen, Landover, MD

A spokesperson said it was against company policy for individual facilities to provide the type of information asked for. He referred us to their home office in Petersburg VA.

Virginia Linen, Petersburg, VA

When asked if a survey form were available, several copies of the form were sent, with the hope of collecting data on different sizes of facilities. (A copy of the form sent is included at the end of this Appendix.) As of the last contact (12 April 1994), the forms had been received and turned over to the company president for disposition.

Contacts with Laundry Trade Associations:

Uniform and Textile Service Association (UTSA) (formerly the Institute of Industrial Launderers)

UTSA commissioned a survey of wastewater and energy use in member facilities. The survey was conducted in late 1992. Mr. Geoffrey A. Northey furnished copies of filled out surveys from 22 facilities, which provided the primary source of data for the

comparison of military and commercial laundry facilities presented in this report. A copy of an equipment list for one facility was also received from Mr. Northey. UTSA also markets a computerized maintenance management system that incorporates data on an equipment-by-equipment basis. It may be possible to obtain more detailed data from the users of this system, with proper permission and clearances.

International Fabricare Institute

Mr. Ken Faig sent a copy of the March 1992 issue of *Special Reporter*. The title of the issue is "Getting the Most For Your Energy Dollar." The discussion focused on ways to conserve energy and water in the various items of laundry equipment. The only pertinent quantifying statement is "The energy cost for a pound of laundry is $0.05." A copy of the article is included in Appendix D.

The National Association of Institutional Linen Management

This organization referred the researchers to Mr. Chip Webster of Servicemaster Corp., who is associated with laundry layouts and management of over 200 facilities. Information of the type requested is confidential and cannot be released without the consent of each specific customer.

Textile Care and Allied Trade Association

Is a small (two person) operation and does not collect any data pertinent to this study.

Textile Rental Services Association (TRSA)

TRSA supplied a copy of an article titled "Industry Energy Consumption Drops, According to Survey," which appeared in the June 1992 issue of *Textile Rental* magazine. Results of energy and water use surveys of four large chain companies are presented. These results are compared with other available data in this report. A copy of the article is included in Appendix D. TRSA also has available a two-volume publication titled "How to Reduce Costs Through Energy Conservation."

Commercial Laundry Survey Form

LAUNDRY PLANT ENERGY EFFICIENCY STUDY
ENERGY USE SURVEY

1. PLANT/PRODUCTION DATA

IDENTIFICATION AND PRODUCTION INFORMATION	
FACILITY NAME	
DATE OF SURVEY	
TYPICAL OPERATION # Days/week # Hours/day Time of operation (From.. to..)	
NUMBER OF EMPLOYEES	
PLANT OUTPUT (lbs/day) Daily average Maximum capacity	
PLANT ANNUAL OUTPUT (lbs/year)	

2. ANNUAL ENERGY CONSUMPTION AND COSTS

ITEM	USE	$/UNIT	COST
ELECTRICITY (kWh)			
NATURAL GAS (MCF)[1]			
OIL (#) (gal)			
DOMESTIC H_2O (gal)			
HOT H_2O (gal)			
STEAM (lbs)			
OTHER ( )			
TOTAL ENERGY COST			

3. ANNUAL COSTS

ITEM	COST
ANNUAL DIRECT LABOR COST	
ANNUAL SUPPLIES COST	
ANNUAL MAINTENANCE LABOR COST	
ANNUAL OVERHEAD COST	
OTHER	

[1] MCF - million cubic feet

4. LAUNDRY EQUIPMENT

EQUIPMENT DESCRIPTION	UNITS	CAPA CITY	ENERGY USE								AGE	OPERATION	
			ELECT.	GAS	OIL	STEAM			HOT WATER				
	#	lbs/hr	kW	scf/hr[1]	gal/hr	lbs/hr	psi	° F	gal/hr	° F	Years	hr/day	From..To..

1 scf/hr - standard cubic feet per hour

5. BOILER ROOM EQUIPMENT
(Boilers, hot water heaters, heat exchangers)

EQUIPMENT DESCRIPTION	UNITS	ENERGY SOURCE/FUEL		OUTPUT					DIST. MEDIA	ENERGY SHARE FOR LAUNDRY	AGE	OPERATION	
		TYPE[1]	CONS[2]	STEAM			HOT WATER						
	#	( )	( )	lbs/hr	psi	°F	gal/hr	°F		%	years	hr/day	From..To..

1 G - Natural gas, O - Fuel oil, E - Electricity, C - Coal, S - Steam fed heat exchanger, H - Hot water fed heat exchanger.

2 Please, show consumption unit (ton/hr, scf/hr, gal/hr, etc)

6. ENERGY CONSERVATION MEASURES FOR LAUNDRY AND BOILER ROOMS

	YES	NO
LAUNDRY EQUIPMENT		
Microprocessor controls on laundering equipment		
Fully-automated (hands-off) washroom		
Heat recovery from dryer exhausts		
Preventative maintenance schedule		
Isolation valves for idle equipment		
Continuous batch washers		
Ozonation system		
Thermal fluids		
Direct fired water heater		
Waste water heat reclaimer		
BOILERS		
Boiler combustion control system		
Stack temperature measured		
CO_2, CO, O_2, NO_x analyzed		
Blowdown on boilers (Continuous/periodic)		
Damper controls		
Condensate return system (if yes, % return)		
Boiler stack economizer		
Fuel metered		
Electricity metered		
Water metered		
Steam metered		

LIST OF OTHER ENERGY CONSERVATION EQUIPMENT/TECHNOLOGY USED

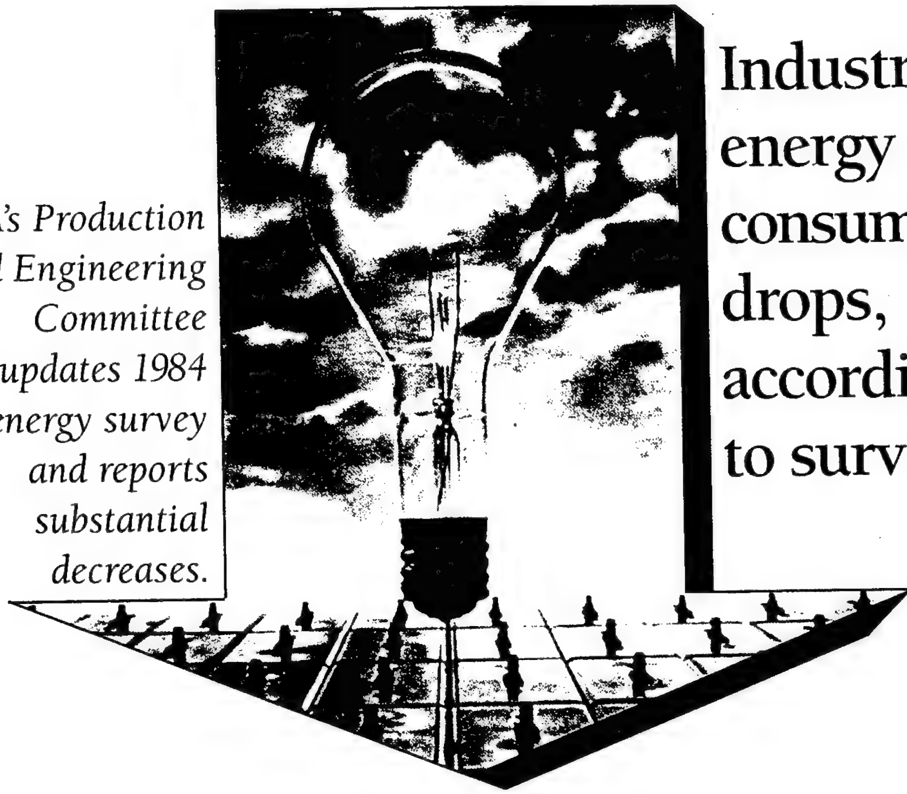
1. ____________________

2. ____________________

3. ____________________

Appendix D: Reprints of Selected Laundry Articles

"Industry Energy Consumption Drops, According to Survey," *Textile Rental* (June 1992)



TRSA's Production and Engineering Committee updates 1984 energy survey and reports substantial decreases.

Industry energy consumption drops, according to survey

Long regarded as an energy-efficient, recycling industry, textile rental appears to be making greater strides in this direction, according to a survey conducted in late 1991 by TRSA's Production and Engineering Committee. The survey of four large chain companies shows a substantial decrease in boiler and dryer fuel and water usage with a slight increase in electrical consumption compared with a 1984 industrywide survey.

For the recent survey, participating companies provided consumption data of three utilities by per pound of production for each of the geographical regions in which they operate. To ensure confidentiality, company names and the areas for which each provided data are not reported. Instead, survey data have been compiled for two regions: northern and southern states.

TRSA's two prior energy surveys (1984 and 1982) also reported data according to these two major climatic zones, anticipating that plants in northern states would consume more energy than those in southern states. For this analysis, the geographical areas used in reporting data have been grouped according to Chart 1.

Chart 1: Energy survey geographical regions

Geographical areas used by companies in reporting data	Regrouped into north/south regions
North East Northeast Northwest Midwest	North region
South West Southeast Southwest	South region

Survey results

The data reflect a significant reduction in natural gas/fuel oil use *(Chart 2)* and water consumption *(Chart 4)* in both northern and southern plants. However, use of electricity has increased slightly *(Chart 3)*.

These findings have been determined by taking averages submitted by the four companies and then averaging these figures again. Mathematically, this is not a proper procedure. However, the results provide benchmark figures against which rental operators can compare their own figures, and the improvement shown is of such a degree that it represents industrywide improvement—although possibly not to the same extent as the data show.

Considering the changes TRSA knows to have taken place in the industry, the data appear logical. For example, much of the older washing equipment has been replaced with more modern equipment that uses significantly less water. Most plant managers who still use the older equipment have adjusted their formulas to use less water, especially heated water. Much work also has been done to reuse water—both to recycle clean rinse water into the initial operation of subsequent loads and to

Chart 2: Natural gas and fuel oil consumption in Btu per lb. of production

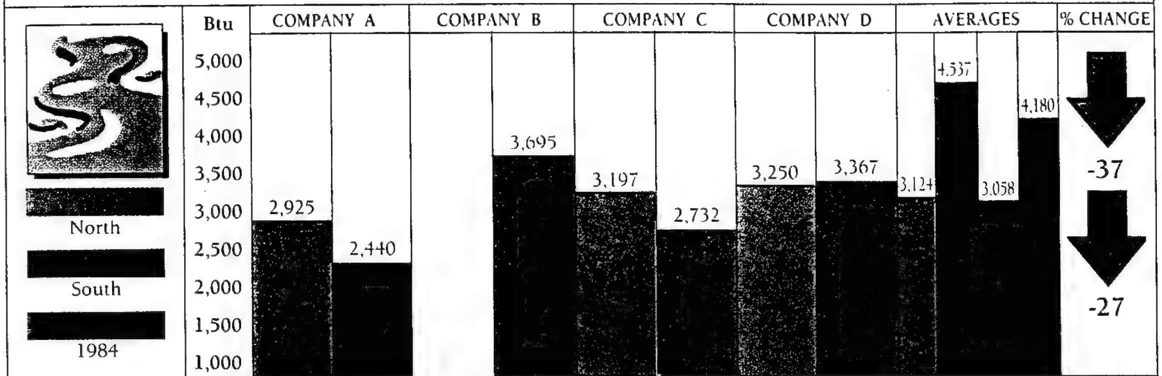


Chart 3: Electrical consumption in kwh per 100 lb. of production

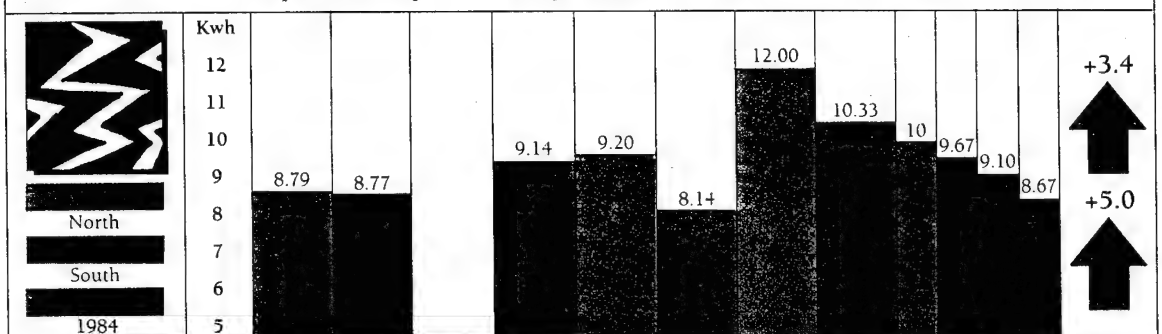
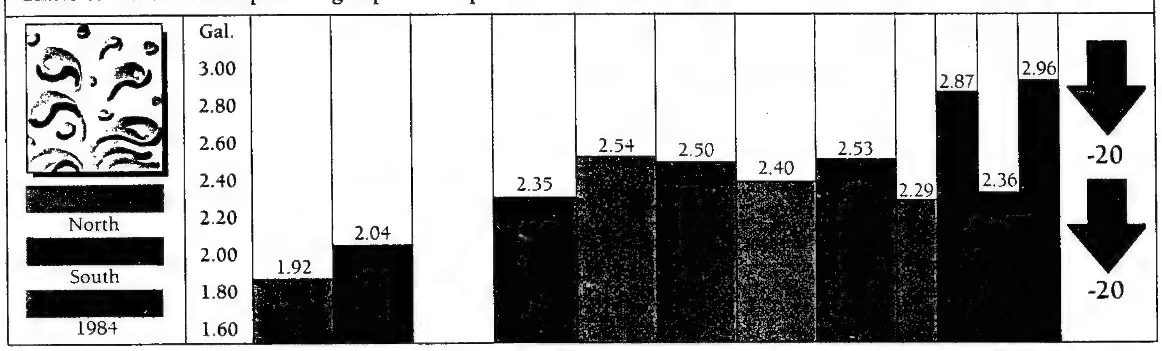


Chart 4: Water consumption in gal. per lb. of production



reclaim wastewater for processing and reuse.

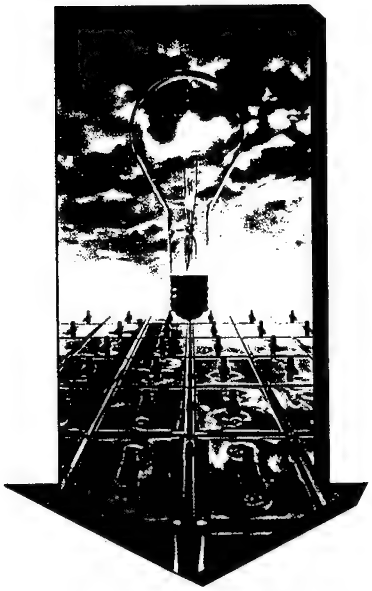
The reduction in the amount of water used logically results in a corresponding reduction in the energy used to heat it. Recent improvements in the efficiency of some newer extractors result in shorter drying cycles in tumbler/dryers or, in some cases, bypassing the operation.

Some of these changes can be expected to increase costs in other areas. This is reflected in the higher electricity use to power the newer high-output washers and mechanical extractors and to light the plants. Many plants are operating more hours per day than in the

Energy-saving publications available from TRSA

Two TRSA publications can help you identify energy-saving opportunities in your plants:

- ❑ *How to Reduce Costs Through Energy Conservation, Vol. I* (#71301)
  This 24-page booklet describes how to reduce energy costs by checking specific energy use areas. Major categories featured are plant buildings, processes and equipment, electric power, and vehicle fuel conservation. Useful as a comprehensive checklist to survey all areas of energy consumption for possible savings.
  Member price $5; retail $10
- ❑ *How to Reduce Costs Through Energy Conservation, Vol. II* (#71372)
  This 96-page book is a compilation of material on energy management and energy conservation techniques for specific kinds of plant equipment previously appearing in either *Textile Rental* magazine or TRSA newsletters. Vol. II should be used as a companion piece to Vol. I. Included in Vol. II is a chapter on monitoring and measuring energy consumption.
  Member price $15; retail $30



past to better use the fixed investment in plant and equipment.

Comparing your energy consumption

Your plant's consumption of any of these three utilities may be better or worse than the consumption rates shown here for valid reasons. In addition to the factors mentioned, soil content can be a major determinant of the amount of heated water and energy used.

Also, the way you determine pounds of production can affect your consumption rate. TRSA's Production and Engineering Committee believes that pounds of production should be stated in terms of clean, dry weight calculated from pieces produced. That is the count of good pieces coming from the various finishing operations multiplied by a weight factor for each piece.

Another determinant of fuel consumption is the geographical location of the plant. Plants located in northern cities with cold climates can be expected to use significant amounts of fuel for space heating.

How to get a handle on energy costs

With today's increased competition and low profit margins, you or your plant manager should regularly measure and record consumption of water, electricity, and gas/fuel oil on a per-pound basis. By comparing these rates with a benchmark rate, you can spot trends in consumption over time and take action when needed. The sidebar below offers some useful formulas for starting this process. If you have any questions about the survey, contact Clyde Blaco at TRSA.

Tips for measuring energy consumption

Water

Water consumption is usually expressed as gallons used. For any specific period of time:

$$\frac{\textit{Gallons used}}{\textit{Pounds produced}} = \textit{Gallons per pound}$$

Therefore, if 22,024,000 gal. of water is consumed and 7,269,000 lb. of merchandise is processed during a set period of time, the consumption rate would be:

$$\frac{22{,}024{,}000 \textit{ gal.}}{7{,}269{,}000 \textit{ lb.}} = 3.0 \textit{ gal. per lb.}$$

If your water company (or its meter) provides consumption data measured in cubic feet of water, convert the number of cubic feet consumed to gallons consumed. This is done by multiplying cubic feet by 7.48.

Cubic feet of water x 7.48 = Gallons of water

Electricity

Consumption of electricity is measured by the kilowatt hour—the amount of energy delivered by an hour-long flow of 1 kw of electric power. A 100-watt bulb burning for 10 hours will use 1 kw of electric energy (100 watts multiplied by 10 hours equals 1,000 watt hours, or a kilowatt hour).

Kilowatts can be converted to Btu by multiplying by 3.413.

Kilowatt hours should be related to pounds produced:

$$\frac{\textit{Kilowatt hours used}}{\textit{Pounds produced}} = \textit{Kilowatt hours per pound}$$

Natural gas/fuel oil

Natural gas consumption is measured in several ways. These, and their Btu equivalency, are shown in the following table:

Unit of measurement	Btu equivalency
Therm	100,000
1 cu. ft. (CF)	1,000*
100 cu. ft. (CCF)	100,000*
1,000 cu. ft. (MCF)	1,000,000*

For the most commonly used types of fuel oil, the Btu ratings are:

Type of fuel oil	Btu equivalency
No. 2 fuel oil	140,000 Btu/gal.
No. 5 fuel oil	148,000 Btu/gal.
No. 6 fuel oil	150,000 Btu/gal.

To calculate the consumption rates for natural gas, fuel oil, or any other type of fuel, convert the quantity of fuel used into its Btu equivalency and then relate this to the pounds of production.

**The number of Btu in a cubic foot of natural gas varies from place to place and from time to time, but 100 cu. ft. usually contains more than one therm (100,000 Btu). To obtain the exact Btu content of natural gas, contact the gas utility. The figures shown are usually close enough for monitoring fuel-usage rates.*

The reason for making this conversion is that the Btu is the common denominator into which a known quantity of any fuel or electricity may be converted. A plant using a No. 2 fuel oil and natural gas can't add these consumption rates together without first converting them to a common denominator. By the same token, if a plant uses No. 2 fuel oil only and wants to compare its fuel consumption rate to that of another plant that uses natural gas only, conversion is needed to make the comparison.

For a plant that consumed 600 gal. of No. 2 fuel oil and 2,250,000 cu. ft. of natural gas to process 600,000 lb. of merchandise, the arithmetic involved in calculating the Btu per pound processed is as follows:

600 gal. of No. 2 fuel oil x *140,000 Btu per gal.* = *84,000,000 Btu*

plus:

2,250,000 cu. ft. of natural gas x *1,000 Btu per cu. ft.* = *2,250,000,000 Btu*

Total number of Btu *2,334,000,000 Btu*

$$\frac{\textit{2,334,000,000 Btu}}{\textit{600,000 lb. processed}} = \textit{3,890 Btu per lb. processed}$$

To simplify the division of such large numbers, move the decimal point five or six places to the left in the numbers above and below the line. Moving it five places to the left results in the following:

$$\frac{\textit{23,340 Btu}}{\textit{6 lb.}} = \textit{3,890 Btu per lb.}$$

TRSA

"Getting the Most for your Energy Dollar," *Special Reporter*, Vol 20, no. 2 (March 1992).

INTERNATIONAL FABRICARE INSTITUTE
SPECIAL REPORTER
The Association of Professional Drycleaners and Launderers
12251 Tech Road, Silver Spring, Maryland 20904 (301) 622-1900

Getting the Most For Your Energy Dollar

Each pound of drycleaning processed contains an energy cost of $0.12 or $0.27 for a two piece suit. The energy expense consisted of fuel, electricity, water, and sewage. One would expect the energy cost of a pound of laundry to be more expensive; however, it is considerably lower than drycleaning. The energy cost for a pound of laundry is $0.05. The power consuming machinery and component parts in drycleaning raise the energy cost per pound.

According to the IFI cost survey, utility costs are about 5.5 to 6 percent of total sales. Anything which can be done to reduce the energy costs should have high priority.

Fuel Conservation in the Power Plant

Conservation of fuel should always be a concern of good management from a cost standpoint even when a shortage of fuel does not exist. Proper boiler operation saves many dollars and, possibly, some costly breakdowns.

Your power plant transforms British Thermal Units (BTUs) of fuel into steam for heating water and use in machines that process work. Our purpose here is to talk about getting the most out of the BTU input. Many factors affect the efficiency of your boilers, regardless of the type of fuel you use.

If you burn oil, gas, or coal, how long has it been since the actual mixture of air and fuel has been checked? Insufficient air will cause incomplete combustion and a smoking stack. On the other hand, an excess of air will reduce the BTU transfer.

There is a large variance in the instruments used in different plants to measure the effectiveness of the boiler. Flue gas temperatures as well as constant CO_2, and CO, and O_2 recorders indicate how well the boiler is transferring the BTU input into processing steam. If these meters are not available, many gas and oil companies will check your stack temperature and use an Orsat meter to determine if you have the proper mixture of air and fuel.

High stack temperatures are good indicators that scale is forming on the tubes, preventing proper heat transfer. Tube burn out and wasted fuel are a result of scale formation.

Correct treatment of the boiler feed water is most important and should be determined by a technician from one of the many companies supplying boiler treatment compounds. Once you determine the needs for your particular boiler feed water, see that these needs are filled so scale will not accumulate in the boiler and tubes.

The amount of blow-down needed for your boiler will also be established in tests the boiler feed water technician can make. When plants use soft water, other factors such as pitting and corrosion will be a factor in boiler treatment compounds.

Check that all insulation originally designed for your boiler is in place and has not deteriorated or been lost. At the same time, check that all the steam headers and steam lines in the power plant are properly insulated, as the heat loss from the larger headers can be very great. Repack all steam valves that show leakage. Any flange joints in the larger headers should be checked for leaks and promptly repaired if any exist.

While the boiler plant is inspected internally and externally once a year by your insurance company, it is wise to check the boiler internally both on the fire side and water side semiannually to ensure against scale buildup, as well as leaks in the refractory and brick surfaces of the fire side of the boiler. Remember, soot on the tubes as well as scale in the drum and the tubes will cut down on heat transfer and boiler efficiency.

Boiler feed pumps should be checked for leaky packing as well as the temperature of the returning condensate. Pumps can only pump liquids and steam bind where the condensate is steam. Plants with steam heated hot water heaters usually run the condensate through a hot water tank before returning it to the condensate tank.

Trapping throughout the plant will have a great effect on the temperature of condensate return. If traps are not working properly, the temperature of the return condensate tank will be excessively high, causing lost steam through the tank vent to the atmosphere, plus the addition of excessive chill water to the condensate tank.

Start up and close down times can be very important in fuel conservation since most systems will have sufficient steam pressure to carry the load if the boiler is shut down 10 to 15 minutes before the plant ceases operation. Starting the power plant as late as possible before steam is needed for processing can also result in fuel savings. Every half hour of later starting or earlier close down will mean savings in fuel used over a period of a week.

Perhaps you need to run only one department on Saturday. Your piping should be arranged so that departments requiring steam can be isolated and you do not have to provide it for the entire plant. Likewise, where steam is required, just to heat the building during cold weather, the boiler should be run at low instead of high pressure to prevent costly "freeze ups" and also conserve the fuel needed for high pressure. Many plants have used a small boiler or space heater for this purpose, and have realized a savings in fuel.

In laundry operation, heat reclaimers can save many fuel dollars since waste water from the washroom contains many BTUs which can raise your incoming cold water temperature, say, 40 degrees. If it is possible to raise your incoming water 40 degrees, this is equal to 1/4 of the total heat required to raise 60° F water to 180° F. Since about 65 percent of the fuel burned is for heating water, you save many BTUs on the total heating bill. The initial cost of the heat reclaimer may seem high, but the savings in fuel dollars can make it a very profitable investment. If you have a heat reclaimer, be sure that it is kept clean so that maximum heat transfer from the waste water is obtained.

Hot water storage tanks and heaters should be inspected for scale, sludge, pitting, and corrosion. If you require 160° F hot water, you are wasting fuel when your controls allow this temperature to rise to 180° F. Hot water storage tanks and heaters should be insulated to conserve BTUs of the heated water.

Proper operation of all boiler controls should be inspected, such as boiler feed pump controls and low water cutoff controls. Operating personnel should be blowing down these controls at least twice daily to ensure proper operating water level in the boiler as well as ensure that the low water cutoff is operating properly should low water develop. The blow-down valves should not leak. Since they are exposed to the solids and sludge being blown from the boiler, these valves will often not seat correctly and allow a loss of steam. Safety valves should be seated tightly, not allowing them to sizzle and lose steam. The fire eye, the pressure control, and the low water cutoff are wired in series. Check all three. Failure in any of these operations will cause an immediate shut down of the burner.

Since air compressors are usually considered power plant equipment, all electrical wiring and controls should be inspected. Check water-cooled jackets for scale or other obstructions. Incoming air filters should be kept clean and air storage tanks should be drained daily to prevent the build-up of water in the air lines. Fins on the heads of air-cooled compressors should be kept free of lint and dirt to prevent overheating. It is wise to draw the incoming air for the compress from outside the building.

A preventive maintenance system can be very effective in saving energy and preventing breakdowns. It ensures that each piece of power plant equipment is being checked for its needed maintenance, and provides a record of parts and maintenance time needed to keep the piece of equipment in proper running condition. This record indicates when replacement is necessary due to large repair bills, and also prevents expensive breakdowns.

The power plant checklist on page 3 should help you find energy losses.

Insulation

Insulating all hot pipes is the first step in saving fuel and reducing the inside temperature of the plant. This has one of the best payback records of any equipment or supplies. The savings in fuel will pay for the insulation in three to six months. This kind of payback is hard to beat. Make sure that not only pipes but tanks requiring insulation are insulated.

Steam Leaks

Steam leaks must be repaired as quickly as possible. Many of the leaks are from the packing gland around the stem of a valve. A fraction of a turn will stop the leak. Fittings and valves are often the source of leaks. Keep after the leaks as they will only get worse.

Trapping

The first step to maximum steam utilization in steam-heated equipment is proper trapping. We recommend the use of individual traps on ironers to prevent short circuiting of some chests on the ironer as a result of the difference in condensing rates from the first to last chest.

To determine if a trap is working properly, check the temperature on both the inlet and outlet sides. Normally, the temperature will be considerably less on the discharge side. If it is not, you may have a blow-through condition which is causing less efficiency in the unit and will raise the temperature of the condensate, causing more flash steam at the receiver tank. This will usually mean that air and carbon dioxide gas are not being eliminated, which will cause corrosion and further reduction in efficiency as a result of the insulating effect of air in the steam. Checking traps for proper operation, particularly if you have not done so for a while, can improve the operating efficiency of the boiler. It will also save you money and fuel.

Valves to Isolate Equipment

It has always been our recommendation that your finishing or ironing equipment have valves on both the steam lines and condensate returns so that, if necessary, one unit or one press can be turned off for maintenance purposes without having to disable other equipment.

Checklist for Power Plant Operation

Boilers

- ☐ Are you getting the maximum efficiency in your BTU input compared to steam produced?
- ☐ All controls working properly
- ☐ Stack temperature correct—maximum 150 degrees over temperature of steam produced
- ☐ CO_2, CO, and O_2 analyzed
- ☐ Proper blow down of boilers
- ☐ Damper controls working properly

Condensate

- ☐ Pumps working properly—no leaks
- ☐ Traps working properly—not overheating the condensate tank
- ☐ Condensate being returned to the boiler at the correct temperature

Piping and Valves

- ☐ Leaky valves repaired and repacked
- ☐ All lines insulated properly
- ☐ All steam leaks in pipe fittings and flange joints repaired

Hot Water Tanks

- ☐ All internal surfaces checked for scale and sludge, corrosion, and pitting
- ☐ All external surfaces properly insulated
- ☐ Operating controls functioning properly to maintain desired temperature
- ☐ Many hot water tanks have a separate coil to utilize the heat from the condensate before it goes to the condensate tank. If it does not have a coil, use a heat exchanger for this purpose

Boiler Treatment Compound

- ☐ Correct chemicals being used
- ☐ Proper injection system being maintained
- ☐ Daily log of test results
- ☐ Supervision by technician from manufacturer of chemicals being used

Heat Exchangers and Heat Reclaimers

- ☐ Check proper temperature rise on outgoing water line
- ☐ Heat reclaimers are kept clean and operating properly

Air Compressors

- ☐ Condition of all electrical wiring and controls
- ☐ Check discharge valves
- ☐ Check water-cooled compressor jackets for scale or obstruction
- ☐ Check air storage tank
- ☐ Check air inlet filters—draw air from outside the building

Log of Operation

- ☐ Fuel used
- ☐ Electricity used
- ☐ Steam produced
- ☐ Water used

Preventive Maintenance System for Power Plant

- ☐ Accurate, systematic checking of all power plant equipment
- ☐ Records of cost, parts, and labor for each piece of equipment

Even when this procedure is followed, we have seen instances where any number of presses are standing idle with full steam pressure applied.

When you have units which are not going to be used during the day, these valves should be turned off. This will save fuel and, especially in warm climates or in summer, will reduce the heat which requires additional ventilation or cooling to keep employees as comfortable as possible. Better planning can be the key to increased efficiency in fuel utilization. In multi-ironer plants the standard procedure is to heat up all the units even though one may not be used for several hours or perhaps not at all unless there is a breakdown. Usually an ironer can be warmed up in no more than an hour, yet many are heated from nine to ten hours per day and used only an hour or so or perhaps not at all. Turn those valves off and save money and fuel.

Timers and Controls

Most newer types of finishing equipment have automatic controls or timers to govern the time the press is closed, or the time steam or air is applied. In many plants, these controls or timers have not been checked for the proper setting; they should be .

Where excessive time is used in these functions, your loss is a double-headed monster. If the air cycle is too long, your electricity bill goes up and you waste energy. The same goes for steaming cycles and press closed time—excessive steam is consumed. And in both cases, the operator efficiency is lowered as a result of the total elapsed time between cycles and/or pieces.

Hot-head Presses

For maximum efficiency and utilization, presses should be kept clean. There is usually starch in items which are pressed in laundry departments and a certain amount of starch will adhere to the press polished surface and turn brown from the heat. This coating has an insulating effect and should be cleaned off with a non-abrasive cleaner and bronze wool. Steel wool should NOT be used as it will remove some of the polished finish.

Tumblers

Many tumbler installations are not piped adequately because of a misunderstanding of the steam requirements for these rather simple machines. The average 32 to 50 pound rated tumbler will consume about four boiler horsepower per hour. Four tumblers will require more steam than a conventional six-roll ironer. These are relatively heavy steam users.

As long as the tumbler runs, it is pulling power from the boiler. The fan pulls air through the steam coil and exhausts the air up the stack. Once the load is dry, this is a waste of time and money. It will also, on occasion, raise the temperature of the load to a point where some items will be ignited and you have not only wasted money and steam, but you have a claim for customer goods or you have burned up part of your inventory.

On tumblers that do not come equipped with timers, it is fairly easy to put kitchen timers on the units. In some cases, these can be wired into the electrical circuit, or they may only serve to sound a bell or a buzzer to remind the operator to remove the load. These should also be fixed so that they can be set for only an average drying time.

Tumblers which have lint traps in a drawer at the base of the unit should be cleaned out several times a day to keep a free flow of air and keep efficiency high. Clogged lint traps drop efficiency and raise operation costs. The steam coil should also be kept free of lint to prevent reduction of air flow through the fins of the coil. Keeping equipment running at peak efficiency is the key to maximum utilization of power.

Gas-fired tumblers should be tested to ascertain that proper pressure in the incoming gas supply is maintained. This is normally recorded as a certain amount in inches of water and should be regulated to the specification established by the manufacturer. Additionally, the fuel-air mixture should be checked for proper combustion. Normally the local gas company representative will check these for you.

If your gas tumbler does not have a sensing control for degree of moisture in either conditioning or drying loads, check to make sure the timers are being set for proper times. If your workload now consists of higher quantities of blends rather than cotton, you can probably reduce the timer settings. Also, check the time on fully dried loads as many plants over dry and this wastes fuel and reduces the total capacity of the tumbler.

Flatwork Ironers

Besides the things mentioned elsewhere in this *Reporter* about ironers and trapping and turning off steam when it is not in use, there are several other checkpoints for conservation.

When the ironer will not be used for short periods of time (lunch hour), the pressure should be taken off and the machine should be stopped. This will give added life to aprons and padding, as well as save electricity. If the ironer is also equipped with a canopy, the exhaust motor can be turned off to prevent air being pulled from the chest area and exhausted to the outside atmosphere. This will save steam and electricity and maintain the temperature so the unit will be ready to pick up full production at the end of the lunch hour.

You should also examine the type and quantity of

15 Super Savers—Steam Usage Checklist

- ☐ Make sure pipes and hot water storage tanks are insulated.
- ☐ Check for steam leaks throughout the plant. Repack valves that are leaking.
- ☐ Check all traps for proper operation—replace or repair inoperative ones or those that are blowing through.
- ☐ Check equipment which is not being used to make sure such equipment is turned off. If individual valves have not been installed to accomplish this, put valves in as needed. Make sure that valves which are turned off are seated properly and not leaking steam into unused equipment.
- ☐ Check timers and controls for correct operation. Do not oversteam, overblow, or overdry in tumblers or presses.
- ☐ Check condition of press surface areas—keep clean and bright for better heat transfer.
- ☐ Check tumblers for adequate piping and ducting.
- ☐ Check timers and/or timing of drying and conditioning loads.
- ☐ Check lint traps for free air flows.
- ☐ Check steam coils for lint buildup—clean them as required.
- ☐ Check pressure of gas and combustion on gas-fired tumblers.
- ☐ Check ironers for pressure removal during periods of inactivity and make sure motors are turned off.
- ☐ Turn off vents in canopy when ironer is not in use.
- ☐ Check workload on ironer to be sure proper speeds are used.
- ☐ Check padding, covers, aprons, and mechanical condition for maximum production.

work being processed. If the workload has changed in nature, you may not have adjusted the speed to produce the maximum amount of work in the least possible time. The speed should be such that items will dry in one pass. If you have a quantity of items which have to be fed into the ironer twice to dry, you can save by reducing the speed. The second time through will usually be inefficient both in terms of handling and in fuel utilization since the item will be almost dry after the first pass and the second expends as much time and heat all over again. It is wasteful.

If your workload has a high percentage of blends and you are still using the conditioning tumbler, you should check to see if you can eliminate the conditioning and still maintain the same productivity.

Naturally, proper maintenance of the ironer's mechanical condition, padding, covers, and aprons will contribute to the overall efficiency and prevent waste of energy.

Conservation of Electricity

Purchase power in many plants will be in excess of 25 percent of the amount spent for oil or gas. It is another important energy source to try to save as much as possible. A number of checkpoints follow.

Fluorescent lamps give much greater illumination per watt then incandescent bulbs and have a life expectancy of more than ten times the incandescent bulb. A 40-watt fluorescent tube produces more light then a 100-watt incandescent bulb for less than half the energy cost.

Heavy duty motors expend the most power when starting. Plants using centrifugal extractors should be sure loads are carefully balanced before starting the extractor. This avoids having to stop and restart these large motors.

Multiple extractor starting times should be staggered so that the heavy draw on current it takes to start them all will not be on the line all at once. This will help to keep the demand rate at a lower level and save money on the power bill. This same idea will be beneficial for plants with multiple washer-extractors. Staggering the starting times will reduce the number of occasions when two or more will be going into extract at the same time.

Turn off all equipment as soon as possible after it is no longer needed. Plant shutdown at the end of the day should be made the responsibility of one individual or a number of people with definite procedures to make sure that everything no longer being used is turned off. Post signs, at doors to storage areas or other areas used only occasionally to remind people to turn out lights when leaving the area. Make a checklist of outdoor lights, signs, night lights, etc., to make sure these are not burning during daylight hours. Automatic dusk to dawn switches can be put on some of these circuits.

Clean or replace filters in equipment and ventilating systems. This will keep air flowing freely, thus the motors will use less current.

Eliminate excessive voltage drops. If expansions in the operation have included new equipment and existing lines have been extended for additional service, excessive line drops will cause motors and equipment to draw more current and run at higher ambient temperatures, causing inefficient operation.

Check machine loading procedures to ascertain that full loads are processed each time you operate your powered machinery. There is virtually no difference in power consumed with partial loads, but in order to handle the same total tonnage, partial loads will require more running time, use more energy, and cost more money.

Consider earlier starting times during summer months to take advantage of long cool mornings to reduce the need for ventilating and cool systems.

Check fill times in washroom operation. Frequently, a small reciprocating pump can boost water pressure to reduce total running time on automatic wash wheels or washer-extractors. Normally, the timer does not start until the wash level is reached, or rinse level, as the case may be. The pump will speed the fill time, shorten processing time, burn less energy, cost less money, and improve plant efficiency.

Check the length of time extractors are running. If you are handling large quantities of blends, you may be able to reduce the extract time and still get good extraction.

Check maintenance procedures to make sure equipment is in top operating condition. Equipment which does not get proper lubrication can put added drag on motors and require more energy.

Water and Sewage Conservation

Conservation of water and supplies in a laundry washroom can bring multiple savings. Dollar savings can be applied against increased costs for other supplies. And careful use of water can affect savings in the energy needed to heat it.

Water rates have doubled and in some areas even tripled over recent years. Sewer service charges have skyrocketed. Our industry in some areas faces surcharges on water disposal. Just because water always seems to be there, we should not feel free to waste it. We must learn to practice water conversation methods, due to a constantly increasing demand for water and the problems of sewage treatment, sewer and water costs will climb in the months and years ahead.

One of the best ways to undertake these savings and to conserve water is to make a complete water survey of your plant. Your own plant engineers may be competent to conduct such a survey, or an outside consultant can do it for a fee. It will point out areas of savings and tell you the actual dollars and the gallons you can save.

Here are some things to consider in water conservation; many of the points covered here may suggest steps you should take.

Automatic controls on water flow can reduce human error. Floats or pressure controls in tanks or thermostatic valves in cooling circuits can signal water demand to start or stop the water flow when the machines are in use.

Investigate the reuse of water. Water now discharged from compressor jackets and condensers used in drycleaning is reusable. When it is fed back to a cooling tower in an evaporative condenser, you can reuse the water.

Another water conserving program involves **separating rinse water** from sudsing water and reusing the rinse water for subsequent suds operations. The means for separating these wastes as they are dumped from the washers depend on the physical set-up of the washroom. Some ingenuity may be needed to work out a system for each plant. The ideal arrangement would be double gutters under the washers. A tilt board or chute connected to the control chart would direct the suds waste to the sewer gutter and the rinse water to the other gutter which leads to a rinse water holding tank. The rinse water could then be pumped as needed through a filter and then through added piping to any washer calling for water for sudsing.

This water would be soft, alkaline, and warm but would have to be heated by a coil in the tank or by steam injection in the piping or in the washer. A machinery manufacturer can apply a tilt chute and attach it to the controls to work in such a situation.

If two gutters are not available, some plants might prepare a small sump in back of the washer where a chute could dump one rinse. This would ~~have to~~ be pumped to a holding tank right away. Smaller washers with dump valves on a pipe could be fitted with a "Y" in the pipe and dump valve on each branch. One valve could open to discharge the suds waste to the sewer, the other could allow the rinses to flow to a holding tank.

Reusing rinse water for sudsing may save 40 percent of your water. This would mean nearly 40 percent savings on water costs, sewer rental, softening costs, and some heat.

Check for leaking dump valves. Improperly seating valves may allow water to leak out of the washer during washing or rinsing. If enough leaks out to affect the water level gauge, a valve may open admitting more water. This is wasted water. It dilutes the supplies and may require their replenishment. Moreover, it can cause poor washing or redeposition. The same problem results if water level gauges are incorrect and excess water is used in washing or rinsing. Rinse height of 12 inches instead of 10 inches in a 42 x 84 washer (or 300 pound washer-extractor) is equal to 16 gallons in each of four rinses of one wash cycle. This is equivalent to 64 gallons of water per load in a 300 pound machine. Six loads per day means 384 gallons per day, per machine—enough water per year to wash almost 30,000 pounds of work!

Check your meter readings over a period of time, or check the volume charge on your water bill. In a recent

survey of water usage, we found that most laundries were using between 2.5 and 3.5 gallons per pound of work processed. This figure is found by dividing the total gallons used per period (week, month, or year) by the weight of fabrics processed in the same period.

Some plants reported very unusual figures. Some indicated less than ½ gallon used per pounds of load. Other had usage figures of 10, 15, or 20 gallons.

Continuous batch washers or tunnel washers will save large amounts of water. They will use approximately 1½ gallons per pound of linen. Such washers are found in many hospitals doing large quantities of linen.

Weigh loads being prepared for the washroom to ensure that the washers are neither underloaded nor overloaded. Accurate loading will utilize machine, manpower, and supplies at an efficient rate. If you underload washers you still use approximately the same amount of water in the wash formula. If you overload, you may find you have to do reruns on the work being processed.

From 50 to 60 percent of the boiler horsepower required in a plant is generally used to heat hot water. Review your formulas. Can they be altered to cut water consumption? Or can you use less hot water?

Review formulas to determine if extraction time can be reduced. The high volume of polyester in sheeting material should reduce extraction time approximately two-thirds from what it was previously run on all cotton.

Extraction

Consider collecting water from centrifugal or squeeze-type extractors. You may economically recover 15 to 25 gallons of water here for every 100 pounds of laundry processed. Saturated moisture in a load is 0.2 to 0.3 gallon per pound, or 30 gallons per 100 pounds. A plant processing 30,000 pounds a week, then would gain 9,000 gallons of water a week.

Check water levels to be sure that you are getting what the formula calls for in the way of inches of water in the suds or rinse operation. By controlling this accurately, you may well save 8 to 10 gallons per inch in the amount of water used in each step of the wash formula.

Check the condition of the washing equipment. This may help to save water and supplies. Make sure that all water connections are tight. Replace washers in leaky faucets. A faucet leaking at the rate of 200 drops per minute (this is a fast drip but not a steady stream) wastes the equivalent of 5,145.5 gallons in a year. This is not much money in terms of dollars, but this is enough water to wash about 1,500 pounds of fabric. Further, how many faucets, valves, and pipe joints are leaking this fast or faster?

Post the formula for each type of classification being run in that machine. Get a specific size cup or scoop to hold the quantity of supplies needed for each step in the formula. For example, if you need eight ounces of sour in a formula, get a container or scoop at a local hardware store that will measure out exactly that amount. Check all wash formulas, and be sure the proper portion of each supply is being used. If excessive amounts of supplies are used, you'll have to do additional rinsing. Do not use more suds or rinses than are necessary to provide a good wash.

Check water hardness, if your water source gives you water that is over 2.5 grains per gallon, a water softener should be used.

Check and maintain the incoming hot water range. In most plants, maintaining a range of 150° F to 160° F is acceptable. In a plant that may use a large amount of hotter water you can review whether this incoming water temperature should be increased. Generally, any special need for higher water temperatures can be met through the use of steam injection for the isolated case or the limited classification requiring the high temperature.

Classify your loads so as to minimize washing time and still get good washing. Except in the cases of extreme emergency for work flow pattern, never mix heavily soiled work with lighter soiled classifications in the same machine.

Keep a sufficiently high water pressure feeding the supply injectors of your washers. This could vary depending on the moment of demand. Some plants have installed a water injection tank to ensure pressure to flush in supplies.

Use the checklist on page 8 for checking your water and sewage conservation.The second chart on page 8 lists commonly overlooked energy savings.

Water and Sewage Conservation Checklist

- ☐ Reuse of water
  - a) Cooling water to sewer (air conditioning, compressors)
  - b) Rinse water
  - c) Water from centrifugal and squeeze type extractors
- ☐ Leaks
  - a) Faucets
  - b) Valves
  - c) Connections
  - d) Dump valves
  - e) Steam leaks
- ☐ Modify existing washroom formulas
  - a) Reduce extraction time if possible
  - b) Use less hot water
  - c) Use proper formula for type and degree of soil
- ☐ Utilize washroom equipment at rated capacity
- ☐ Maintain water pressure to equipment
- ☐ Maintain proper levels in washers

Energy Savings Overlooked in Many Plants

- ☐ Insulate all hot pipes and tanks
- ☐ Test steam traps for "blow through"
- ☐ Keep boiler burner in tune
- ☐ At night, set back temperatures where heat is kept in plant
- ☐ Check boiler for "coast down" and "start up time"
- ☐ Relocate air compressor intake to outside
- ☐ Install valves to isolate sections of the plant when not working
- ☐ Repair steam and condensate leaks
- ☐ Repair water leaks
- ☐ Repair air leaks

This bulletin was written by Ken Faig, Division Director—Education.

Appendix E: Model Laundry Operations

EQUIPMENT 1/2 MILLION #/YR PLANT	POWER (Kw)	GAS (MMBtuh)	WATER (gal/hr)	STEAM* (MMBtuh)	COST PURCH	COST INST	COST MAINT
Manual Sorting Table					3500	300	186
Laundry Cart 30" x 42" x 28"					4500		239
125 Lb. Washer Extractor	11		812	0.037	40000	3000	2120
85 Lb. Washer Extractor	4.7		288	0.013	10500	750	557
Peristaltic Pump Supply System	0.3		15		5000	450	265
110 Lb. Gas Fired Dryer	5	0.128			4200	400	223
150 Lb. Gas Fired Dryer	2.5	0.045			15100	1000	800
Single Roll 24" Ironer	3			0.2	30800	2200	1632
Double Lane Primary / Cross Folder	2				28000	1600	1484
Small Piece Folding Tables 30" x 72"					1000		53
Steam Air Tunnel Garment Finisher (250 / Hr.)	7.2			0.132	30000	2600	1590
15 Hp. Dual Fired Steam Boiler	1	0.48			9400	800	498
Deaerator Return System	5		5		2200	150	117
Water Softener	0.7				6000	600	318
Gas Fired Hot Water Heater	0.5	1.2			11300	1000	599
10 Hp. Air Compressor	11.1				3800	350	201
					205300	15200	10881

DIRECT LABOR REQUIREMENT (FTE'S)	
Sort	0.5
Wash Room	0.5
Dryers	0.5
Folders/Ironers	1.5
S.P. Folders	1
Garments	0.5
Utility	0.5
TOTAL	5

280#/Hr x 1820 Hrs / Yr = 509,600 #/Yr

/ Worked Hour
509,600 / (5 x 1820) = 56

*Steam is generated by Boiler which is in Gas utility requirement

EQUIPMENT 1/2 MILLION #/YR PLANT	Hour															
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Manual Sorting Table		X	X	X	X	X										
Laundry Cart 30" x 42" x 28"																
125 Lb. Washer Extractor			X	X	X	X	X	X	X							
85 Lb. Washer Extractor			X	X	X	X	X	X	X							
Peristaltic Pump Supply System			X	X	X	X	X	X	X							
110 Lb. Gas Fired Dryer				X	X	X	X	X	X	X						
150 Lb. Gas Fired Dryer				X	X	X	X	X	X	X						
Single Roll 24" Ironer					X	X	X	X	X	X	X					
Double Lane Primary / Cross Folder					X	X	X	X	X	X	X					
Small Piece Folding Tables 30" x 72"					X	X	X	X	X	X	X					
Steam Air Tunnel Garment Finisher (250 / Hr.)					X	X	X	X	X							
15 Hp. Dual Fired Steam Boiler			X	X	X	X	X	X	X	X						
Deaerator Return System			X	X	X	X	X	X	X	X						
Water Softener			X	X	X	X	X	X	X	X						
Gas Fired Hot Water Heater			X	X	X	X	X	X	X							
10 Hp. Air Compressor			X	X	X	X	X	X	X	X						

EQUIPMENT 1/2 MILLION #/YR PLANT(SOA2)	POWER (Kw)	GAS (MMBtuh)	WATER (gal/hr)	STEAM* (MMBtuh)	COST PURCH	COST INST	COST MAINT
Manual Sorting Table					3500	300	186
Laundry Cart 30" x 42" x 28"					4500		239
125 Lb. Washer Extractor	11		770	0.037	40000	3000	2120
85 Lb. Washer Extractor	4.7		274	0.013	10500	750	557
Peristaltic Pump Supply System	0.3		15		5000	450	265
110 Lb. Gas Fired Dryer w/Heat Reclamation	5	0.11			4200	400	223
150 Lb. Gas Fired Dryer w/Heat Reclamation	2.5	0.038			15100	1000	800
Single Roll 24" Ironer	3			0.2	30800	2200	1632
Double Lane Primary / Cross Folder	2				28000	1600	1484
Small Piece Folding Tables 30" x 72"					1000		53
Steam Air Tunnel Garment Finisher (250 / Hr.)	7.2			0.132	30000	2600	1590
15 Hp. Dual Fired Steam Boiler	1	0.43			9400	800	498
Deaerator Return System	5		5		2200	150	117
Water Softener	0.7				6000	600	318
Gas Fired Hot Water Heater	0.5	6.8			11300	1000	599
10 Hp. Air Compressor	11.1				3800	350	201
Waste Water Heat Reclamation System	3				27500	1950	1458
Ozone Generation Equipment	3						0
					232800	17150	12338

DIRECT LABOR REQUIREMENT (FTE'S)		
Sort	0.5	280#/Hr x 1820 Hrs / Yr = 509,600 #/Yr
Wash Room	0.5	
Dryers	0.5	# / Worked Hour
Folders/Ironers	1.5	509,600 / (5 x 1820) = 56
S.P. Folders	1	
Garments	0.5	*Steam is generated by Boiler
Utility	0.5	which is in Gas utility requirement
TOTAL	5	

EQUIPMENT 1/2 MILLION #/YR PLANT(SOA2)	Hour 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Manual Sorting Table		X	X	X	X	X										
Laundry Cart 30" x 42" x 28"																
125 Lb. Washer Extractor			X	X	X	X	X	X	X							
85 Lb. Washer Extractor			X	X	X	X	X	X	X							
Peristaltic Pump Supply System			X	X	X	X	X	X	X							
110 Lb. Gas Fired Dryer w/Heat Reclamation				X	X	X	X	X	X	X						
150 Lb. Gas Fired Dryer w/Heat Reclamation				X	X	X	X	X	X	X						
Single Roll 24" Ironer					X	X	X	X	X	X	X					
Double Lane Primary / Cross Folder					X	X	X	X	X	X	X					
Small Piece Folding Tables 30" x 72"					X	X	X	X	X	X	X					
Steam Air Tunnel Garment Finisher (250 / Hr.)					X	X	X	X	X							
15 Hp. Dual Fired Steam Boiler			X	X	X	X	X	X	X	X						
Deaerator Return System			X	X	X	X	X	X	X	X						
Water Softener			X	X	X	X	X	X	X	X						
Gas Fired Hot Water Heater			X	X	X	X	X	X	X							
10 Hp. Air Compressor			X	X	X	X	X	X	X	X						
Waste Water Heat Reclamation System			X	X	X	X	X	X	X							
Ozone Generation Equipment			X	X	X	X	X	X	X							

EQUIPMENT 2 MILLION # CONVENTIONAL	POWER (Kw)	GAS (MMBtuh)	WATER (gal/hr)	STEAM (MMBtuh)	Hour 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sorting Conveyor	3.2				X	X	X	X	X	X	X									
Soil Storage Rail					X	X	X	X	X	X	X									
400 Lb S/L Washer Extractors	40.65		4927	0.16			X	X	X	X	X	X	X							
200 Lb S/L Washer Extractors	8.9		775	0.026			X	X	X	X	X	X	X							
100 Lb O/P Washer Extractor	4.4		410	0.014			X	X	X	X	X	X	X							
Peristaltic Pump Supply System	0.5		25				X	X	X	X	X	X	X							
200 Lb Dryer	7.6	0.34						X	X	X	X	X	X	X						
100 Lb Dryer	2.6	0.1						X	X	X	X	X	X	X						
Four Station Large Piece Spreader/Feeder	3								X	X	X	X	X	X						
Eight Roll Super Sylon Ironer	13.1			0.93					X	X	X	X	X	X						
Two Lane Primary/Cross Folder	2.9								X	X	X	X	X	X						
Flow Rack	0.25							X	X	X	X	X	X	X						
Small Piece Folder (French Fold)	1.4								X	X	X	X	X	X						
Small Piece Folder (Quarter Fold)	1.4								X	X	X	X	X	X						
70 HP Dual Fired Steam Boilers	3.9	2.1	24			X	X	X	X	X	X	X	X	X						
Deaerator Return System	3.3					X	X	X	X	X	X	X	X	X						
Water Softener	0.16						X	X	X	X	X	X	X							
15 HP Rotary Air Compressors	11.1				X	X	X	X	X	X	X	X	X	X						
Direct Contact Water Heater	6.1	6.4					X	X	X	X	X	X	X							
Compressed Air Dryer	1.2				X	X	X	X	X	X	X	X	X	X						
Double Buck Shirt Body Press	12.1			0.17				X	X	X	X	X	X	X						
Cabinet Shirt Sleeve Press	7.97			0.12				X	X	X	X	X	X	X						
Collar Cuff Press	0.07			0.11				X	X	X	X	X	X	X						
Utility Laundry Press	0.11			0.13				X	X	X	X	X	X	X						
Clean Take Away Conveyor	3								X	X	X	X	X	X						

EQUIPMENT 2 MILLION #/YR H.E. PLANT	POWER (Kw)	GAS (MMBtuh)	WATER (gal/hr)	STEAM* (MMBtuh)	COST PURCH	COST INST	COST MAINT
9 Chamber 50 lb mini CBW	7.3		956	0.47	157000	12000	8321
Single Stage System Press	10.8				70000	5000	3710
CBW System Shuttle Conveyor	5				26000	2200	1378
CBW System 100 lb Dryers	12	0.28			100000	7500	5300
200 lb Dryer	0.3	0.23			24200	1500	1283
150 lb Gas Fired Dryer	2	0.14			8300	600	440
75 lb Gas Fired Dryer	0.8	0.07			2500	400	133
125 lb Solid Mount Washer Extractor	7.5		372	0.033	16500	1600	875
50 lb Washer Extractor	3.7		150	0.013	7200	750	382
200 lb Washer Extractor	6.7		595	0.054	39500	1100	2094
Two Roll 32" Steam Heated Ironer	10.3			0.82	90000	6500	4770
Two Lane Combination Crossfolder/Stacker	1.4				28300	1200	1500
Small Piece Folding Table w/ Dumper	0.4				7000	500	371
Four Station Spreader Feeder	2.1				40100	1500	2125
Clean Work Take Away Conveyor	1				8000	1100	424
10 HP Air Compressor w/ Tank	11.1				4700	800	249
Compressed Air Dryer	1				1400	200	74
Water Softener w/ Brine Tank	0.8				8000	1000	424
Gas Fired Water Heater	2.1	1.05			11300	1000	599
70 HP Gas/Oil Fired Steam Boilers	2	1.79			43000	4000	2279
Boiler Return System	11.2		75		16000	1200	848
Five Pocket Loading Conveyor	2.1				12500	750	663
Cart Dumper					2800	200	148
Domestic Washer	0.9		50		600	60	32
Domestic Dryer	0.7	0.003			400	50	21
Garment Steam Finisher	1.6			0.28	12000	1000	636
Combination Small Piece Gown Folder	1.4				17000	800	901
					754300	54510	39978

DIRECT LABOR REQUIREMENTS (FTE'S)		
Soil and Wash Room	4	1.8 Million #/Yr
Flatwork and Folding	4	7 Worked Hours/day
Cart Makeup and Delivery	2	
Utility Person	1	#/operator Hr
	11	1,800,000 / (11 x 1820) = 89.9

*Steam generation requirement included in gas

EQUIPMENT 2 MILLION #/YR H.E. PLANT	Hour															
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
9 Chamber 50 lb mini CBW		X	X	X	X	X	X	X								
Single Stage System Press		X	X	X	X	X	X	X								
CBW System Shuttle Conveyor		X	X	X	X	X	X	X								
CBW System 100 lb Dryers		X	X	X	X	X	X	X								
200 lb Dryer					X	X	X	X								
150 lb Gas Fired Dryer			X	X	X	X	X	X	X							
75 lb Gas Fired Dryer			X	X	X	X	X	X	X							
125 lb Solid Mount Washer Extractor		X	X	X	X	X	X	X								
50 lb Washer Extractor		X	X	X	X	X	X	X								
200 lb Washer Extractor				X	X	X	X									
Two Roll 32" Steam Heated Ironer				X	X	X	X	X								
Two Lane Combination Crossfolder/Stacker				X	X	X	X	X	X	X						
Small Piece Folding Table w/ Dumper				X	X	X	X	X	X	X						
Four Station Spreader Feeder				X	X	X	X	X	X	X						
Clean Work Take Away Conveyor				X	X	X	X	X	X	X						
10 HP Air Compressor w/ Tank		X	X	X	X	X	X	X	X	X						
Compressed Air Dryer		X	X	X	X	X	X	X	X	X						
Water Softener w/ Brine Tank		X	X	X	X	X	X	X	X	X						
Gas Fired Water Heater		X	X	X	X	X	X	X								
70 HP Gas/Oil Fired Steam Boilers		X	X	X	X	X	X	X	X	X						
Boiler Return System		X	X	X	X	X	X	X	X	X						
Five Pocket Loading Conveyor		X	X	X	X	X	X	X								
Cart Dumper				X	X	X	X	X	X	X						
Domestic Washer				X	X	X										
Domestic Dryer					X	X	X									
Garment Steam Finisher				X	X	X	X	X	X	X						
Combination Small Piece Gown Folder				X	X	X	X	X	X	X						

EQUIPMENT 2 MILLION #/YR H.E. PLANT(SOA2)	POWER (Kw)	GAS (MMBtuh)	WATER (gal/hr)	STEAM* (MMBtuh)	COST PURCH	COST INST	COST MAINT
9 Chamber 50 lb mini CBW	7.3		956	0.47	157000	12000	8321
Single Stage System Press	10.8				70000	5000	3710
CBW System Shuttle Conveyor	5				26000	2200	1378
CBW System 100 lb Dryers W/Energy Recovery	12	0.24			100000	7500	5300
200 lb Dryer W/Energy Recovery	0.3	0.2			24200	1500	1283
150 lb Gas Fired Dryer W/Energy Recovery	2	0.12			8300	600	440
75 lb Gas Fired Dryer W/Energy Recovery	0.8	0.06			2500	400	133
125 lb Solid Mount Washer Extractor	7.5		372	0.033	16500	1600	875
50 lb Washer Extractor	3.7		150	0.013	7200	750	382
200 lb Washer Extractor	6.7		595	0.054	39500	1100	2094
Two Roll 32" Steam Heated Ironer	10.3			0.82	90000	6500	4770
Two Lane Combination Crossfolder/Stacker	1.4				28300	1200	1500
Small Piece Folding Table w/ Dumper	0.4				7000	500	371
Four Station Spreader Feeder	2.1				40100	1500	2125
Clean Work Take Away Conveyor	1				8000	1100	424
10 HP Air Compressor w/ Tank	11.1				4700	800	249
Compressed Air Dryer	1				1400	200	74
Water Softener w/ Brine Tank	0.8				8000	1000	424
Gas Fired Water Heater	2.1	0.35			11300	1000	599
70 HP Gas/Oil Fired Steam Boilers	2	1.79			43000	4000	2279
Boiler Return System	11.2		75		16000	1200	848
Five Pocket Loading Conveyor	2.1				12500	750	663
Cart Dumper					2800	200	148
Domestic Washer	0.9		50		600	60	32
Domestic Dryer	0.7	0.003			400	50	21
Garment Steam Finisher	1.6			0.28	12000	1000	636
Combination Small Piece Gown Folder	1.4				17000	800	901
Waste Water Heat Reclamation System	10				36500	2500	1935
Ozone Generation System	12						0
					790800	57010	41912

DIRECT LABOR REQUIREMENTS (FTE'S)		
Soil and Wash Room	4	1.8 Million #/Yr
Flatwork and Folding	4	7 Worked Hours/day
Cart Makeup and Delivery	2	
Utility Person	1	#/operator Hr
	11	1,800,000 / (11 x 1820) = 89.9

*Steam generation requirement included in gas

EQUIPMENT 2 MILLION #/YR H.E. PLANT(SOA2)	Hour															
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
9 Chamber 50 lb mini CBW		X	X	X	X	X	X	X								
Single Stage System Press		X	X	X	X	X	X	X								
CBW System Shuttle Conveyor		X	X	X	X	X	X	X								
CBW System 100 lb Dryers W/Energy Recovery		X	X	X	X	X	X	X								
200 lb Dryer W/Energy Recovery					X	X	X	X								
150 lb Gas Fired Dryer W/Energy Recovery			X	X	X	X	X	X	X							
75 lb Gas Fired Dryer W/Energy Recovery			X	X	X	X	X	X	X							
125 lb Solid Mount Washer Extractor		X	X	X	X	X	X	X								
50 lb Washer Extractor		X	X	X	X	X	X	X								
200 lb Washer Extractor				X	X	X	X									
Two Roll 32" Steam Heated Ironer				X	X	X	X	X								
Two Lane Combination Crossfolder/Stacker				X	X	X	X	X	X	X						
Small Piece Folding Table w/ Dumper				X	X	X	X	X	X	X						
Four Station Spreader Feeder				X	X	X	X	X	X	X						
Clean Work Take Away Conveyor				X	X	X	X	X	X	X						
10 HP Air Compressor w/ Tank		X	X	X	X	X	X	X	X	X						
Compressed Air Dryer		X	X	X	X	X	X	X	X	X						
Water Softener w/ Brine Tank		X	X	X	X	X	X	X	X	X						
Gas Fired Water Heater		X	X	X	X	X	X	X								
70 HP Gas/Oil Fired Steam Boilers		X	X	X	X	X	X	X	X	X						
Boiler Return System		X	X	X	X	X	X	X	X	X						
Five Pocket Loading Conveyor		X	X	X	X	X	X	X								
Cart Dumper				X	X	X	X	X	X	X						
Domestic Washer				X	X	X										
Domestic Dryer					X	X	X									
Garment Steam Finisher				X	X	X	X	X	X	X						
Combination Small Piece Gown Folder				X	X	X	X	X	X	X						
Waste Water Heat Reclamation System		X	X	X	X	X	X	X								
Ozone Generation System		X	X	X	X	X	X	X								

EQUIPMENT 5 MILLION # CONVENTIONAL	POWER (Kw)	GAS (MMBtuh)	WATER (gal/hr)	STEAM (MMBtuh)	Hour 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
600 Lb S/L Washer Extractors	40.6		7400	0.247			X	X	X	X	X	X	X							
400 Lb S/L Washer Extractors	27.1		3285	0.11			X	X	X	X	X	X	X							
200 Lb S/L Washer Extractors	17.8		1548	0.052			X	X	X	X	X	X	X							
100 Lb O/P Washer Extractor	4.4		410	0.014			X	X	X	X	X	X	X							
85 Lb O/P Washer Extractor	3.7		320	0.011			X	X	X	X	X	X	X							
400 Lb Pass Through Dryers	69.3	3.36						X	X	X	X	X	X	X						
200 Lb Dryer	7.6	0.34						X	X	X	X	X	X	X						
100 Lb Dryer	2.6	0.1						X	X	X	X	X	X	X						
Eight Roll Super Sylon Ironer	13.1			0.93					X	X	X	X	X	X	X	X				
Two Lane Primary/Cross Folder	2.9								X	X	X	X	X	X	X	X				
Large Piece Stacker	0.25								X	X	X	X	X	X	X	X				
Four Station Large Piece Spreader/Feeder	3								X	X	X	X	X	X	X					
Set Clean Work Takeaway Conveyor	3								X	X	X	X	X	X	X					
Sorting/Counting Deck	3.8				X	X	X	X	X	X	X									
Cart Dumper	4.1				X	X	X	X	X	X	X									
Double Buck Shirt Body Press	24.2			0.34					X	X	X	X	X	X	X	X				
Cabinet Shirt Sleeve Press	15.9			0.24					X	X	X	X	X	X	X	X				
Collar Cuff Press	0.14			0.22					X	X	X	X	X	X	X	X				
Utility Laundry Press	0.23			0.25					X	X	X	X	X	X	X	X				
Deaerator Return System	6.1					X	X	X	X	X	X	X	X	X	X	X				
Boiler Blow Down System	0.16					X	X	X	X	X	X	X	X	X	X	X				
30 HP Rotary Air Compressors	29.7				X	X	X	X	X	X	X	X	X	X	X	X				
Direct Contact Water Heater	11.3	12					X	X	X	X	X	X	X							
Water Softener	0.16						X	X	X	X	X	X	X							
Cart Washer	16.7		20				X	X	X	X	X	X	X	X	X					
Small Piece Folder (French Fold)	2.8								X	X	X	X	X	X	X					
Small Piece Folder (Quarter Fold)	1.4								X	X	X	X	X	X	X					
Roll Up Folding Tables/Hoppers	0.95								X	X	X	X	X	X	X					
Floor Scales	0.4				X	X	X	X	X	X	X	X	X	X	X					
125 HP Dual Fired Steam Boilers	4.2	2.9	75			X	X	X	X	X	X	X	X	X	X					
Compressed Air Dryer	1.8				X	X	X	X	X	X	X	X	X	X	X					

EQUIPMENT 5 MILLION #/YR H.E. PLANT	POWER (Kw)	GAS (MMBtuh)	WATER (gal/hr)	STEAM (MMBtuh)	COST PURCH	COST INST	COST MAINT
CBW System Membrane Presses	33.8				195700	10000	10372
CBW System 150# Gas Fired Dryers	88.2	0.58			240000	19000	12720
Two Tier Shuttle Conveyors	19.2				92700	8000	4913
8 Chamber 75 Lb CBW's	68		2625	1.6	298000	21000	15794
125 Lb Washer Extractors	13.2		1400	0.08	60000	4500	3180
85 Lb Washer Extractor	3.7		318	0.02	10500	750	557
Three Roll 32" Ironer	14.7			1.25	133000	7500	7049
Three Lane Primary/Cross Folder	2.9				40000	1200	2120
Double Large Piece Folder	1				8000	600	424
Four Station Large Piece Spreader/Feeder	3				40100	1500	2125
Dryer Unload Conveyor with Incline	0.95				6200	500	329
Clean Work Takeaway Conveyors	3				16500	1200	875
Sorting/Counting Deck	3.8				65000	4500	3445
Cart Dumper	4.1				10500	700	557
Soil Transport/Storage Rail System	1.2				390000	35000	20670
150 Lb Gas Fired Dryers	10.4	0.38			30300	1800	1606
Deaerator Return System	6.1				22500	1800	1193
Boiler Blow Down System	0.16				3200	250	170
30 HP Rotary Air Compressors	29.7				30200	1600	1601
Direct Contact Water Heaters	11.3	1.47			29500	2500	1564
Water Softener	0.16				14300	1200	758
Garment Steam Finishing Tunnel	9.96			0.4	51000	4200	2703
Clean Transport Storage Rail System	1.2				128000	10000	6784
Cart Washer	16.7		20		59000	4800	3127
Small Piece Folder (French Folder)	2.8				35500	1000	1882
Small Piece Folder (Quarter fold)	1.4				17700	500	938
Roll up Folding Tables/Hoppers	0.95				26000	750	1378
Floor Scales	0.4				12800	1200	678
125 HP Dual Fired Steam Boiler	2.6	4.03	75		65000	6000	3445
Compressed Air Dryer	3.6				1400	200	74
					2132600	153750	113028

DIRECT LABOR REQUIREMENT	
Floor Lead Person	1
Soil & Wash Room	7
Flatwork/Folding/Finishing	10
Cart Make Up And Delivery	4
Utility Persons	3
Garment Processing	2
TOTAL	27

7 Worked Hours / Day
5 Days Per Week = 1820 Hrs

#/Worked Hour
5,000,000 / (1820 x 27) = 101.75

* Steam is generated by Boiler which is in Gas Requirement

EQUIPMENT 5 MILLION #/YR H.E. PLANT	Hour															
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CBW System Membrane Presses			X	X	X	X	X	X	50							
CBW System 150# Gas Fired Dryers			X	X	X	X	X	X	X							
Two Tier Shuttle Conveyors			X	X	X	X	X	X	50							
8 Chamber 75 Lb CBW's			X	X	X	X	X	X	50							
125 Lb Washer Extractors				X	X	X	X	X	X	50						
85 Lb Washer Extractor				X	X	X	X	X	X	50						
Three Roll 32" Ironer				X	X	X	X	X	X	X						
Three Lane Primary/Cross Folder				X	X	X	X	X	X	X						
Double Large Piece Folder				X	X	X	X	X	X	X						
Four Station Large Piece Spreader/Feeder				X	X	X	X	X	X	X						
Dryer Unload Conveyor with Incline			X	X	X	X	X	X	X							
Clean Work Takeaway Conveyors				X	X	X	X	X	X	X						
Sorting/Counting Deck		X	X	X	X	X	X									
Cart Dumper		X	X	X	X	X	X									
Soil Transport/Storage Rail System		X	X	X	X	X	X	X	X							
150 Lb Gas Fired Dryers					X	X	X	X	X	X						
Deaerator Return System			X	X	X	X	X	X	X	X						
Boiler Blow Down System			X	X	X	X	X	X	X	X						
30 HP Rotary Air Compressors		X	X	X	X	X	X	X	X	X	X					
Direct Contact Water Heaters		X	X	X	X	X	X	X	X	X						
Water Softener		X	X	X	X	X	X	X	X	X						
Garment Steam Finishing Tunnel					X	X	X	X	X	X	X					
Clean Transport Storage Rail System					X	X	X	X	X	X	X					
Cart Washer		X	X	X	X	X	X									
Small Piece Folder (French Folder)				X	X	X	X	X	X	X						
Small Piece Folder (Quarter fold)				X	X	X	X	X	X	X						
Roll up Folding Tables/Hoppers				X	X	X	X	X	X	X						
Floor Scales		X	X	X	X	X	X	X	X	X	X					
125 HP Dual Fired Steam Boiler			50	70	X	X	X	X	70	50	30					
Compressed Air Dryer		X	X	X	X	X	X	X	X	X	X					

EQUIPMENT 5 MILLION #/YR H.E. PLANT(SOA2)	Hour														
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CBW System Membrane Presses			X	X	X	X	X	X	50							
CBW System 150# Gas Dryers W/Heat Recovery			X	X	X	X	X	X	X							
Two Tier Shuttle Conveyors			X	X	X	X	X	X	50							
8 Chamber 75 Lb CBW's			X	X	X	X	X	X	50							
125 Lb Washer Extractors				X	X	X	X	X	X	50						
85 Lb Washer Extractor				X	X	X	X	X	X	50						
Three Roll 32" Ironer				X	X	X	X	X	X	X						
Three Lane Primary/Cross Folder				X	X	X	X	X	X	X						
Double Large Piece Folder				X	X	X	X	X	X	X						
Four Station Large Piece Spreader/Feeder				X	X	X	X	X	X	X						
Dryer Unload Conveyor with Incline			X	X	X	X	X	X	X							
Clean Work Takeaway Conveyors				X	X	X	X	X	X	X						
Sorting/Counting Deck		X	X	X	X	X	X									
Cart Dumper		X	X	X	X	X	X									
Soil Transport/Storage Rail System		X	X	X	X	X	X	X	X							
150 Lb Gas Fired Dryers W/Heat Recovery					X	X	X	X	X	X						
Deaerator Return System			X	X	X	X	X	X	X	X						
Boiler Blow Down System			X	X	X	X	X	X	X	X						
30 HP Rotary Air Compressors		X	X	X	X	X	X	X	X	X	X					
Direct Contact Water Heaters		X	X	X	X	X	X	X	X	X						
Water Softener		X	X	X	X	X	X	X	X	X						
Garment Steam Finishing Tunnel					X	X	X	X	X	X	X					
Clean Transport Storage Rail System					X	X	X	X	X	X	X					
Cart Washer		X	X	X	X	X	X									
Small Piece Folder (French Folder)				X	X	X	X	X	X	X						
Small Piece Folder (Quarter fold)				X	X	X	X	X	X	X						
Roll up Folding Tables/Hoppers				X	X	X	X	X	X	X						
Floor Scales		X	X	X	X	X	X	X	X	X	X					
125 HP Dual Fired Steam Boiler			50	70	X	X	X	X	70	50	30					
Compressed Air Dryer		X	X	X	X	X	X	X	X	X	X					
Waste Water Heat Reclamation System			X	X	X	X	X	X	X	X						
Ozone Generation System			X	X	X	X	X	X	X	X						

% Indicates amount of average hourly utility usage.

EQUIPMENT 5 MILLION #/YR H.E. PLANT(SOA2)	POWER (Kw)	GAS (MMBtuh)	WATER (gal/hr)	STEAM (MMBtuh)	COST PURCH	COST INST	COST MAINT
CBW System Membrane Presses	33.8				195700	10000	10372
CBW System 150# Gas Dryers W/Heat Recovery	88.2	0.49			240000	19000	12720
Two Tier Shuttle Conveyors	19.2				82700	8000	4913
8 Chamber 75 Lb CBW's	68		2625	1.6	298000	21000	15794
125 Lb Washer Extractors	13.2		1330	0.08	60000	4500	3180
85 Lb Washer Extractor	3.7		300	0.02	10500	750	557
Three Roll 32" Ironer	14.7			1.25	133000	7500	7049
Three Lane Primary/Cross Folder	2.9				40000	1200	2120
Double Large Piece Folder	1				8000	600	424
Four Station Large Piece Spreader/Feeder	3				40100	1500	2125
Dryer Unload Conveyor with Incline	0.95				6200	500	329
Clean Work Takeaway Conveyors	3				16500	1200	875
Sorting/Counting Deck	3.8				65000	4500	3445
Cart Dumper	4.1				10500	700	557
Soil Transport/Storage Rail System	1.2				390000	35000	20670
150 Lb Gas Fired Dryers W/Heat Recovery	10.4	0.32			30300	1800	1606
Deaerator Return System	6.1				22500	1800	1193
Boiler Blow Down System	0.16				3200	250	170
30 HP Rotary Air Compressors	29.7				30200	1600	1601
Direct Contact Water Heaters	11.3	0.53			29500	2500	1564
Water Softener	0.16				14300	1200	758
Garment Steam Finishing Tunnel	9.96			0.4	51000	4200	2703
Clean Transport Storage Rail System	1.2				128000	10000	6784
Cart Washer	16.7		20		59000	4800	3127
Small Piece Folder (French Folder)	2.8				35500	1000	1882
Small Piece Folder (Quarter fold)	1.4				17700	500	938
Roll up Folding Tables/Hoppers	0.95				26000	750	1378
Floor Scales	0.4				12800	1200	678
125 HP Dual Fired Steam Boiler	2.6	3.8	75		65000	6000	3445
Compressed Air Dryer	3.6				1400	200	74
Waste Water Heat Reclamation System	15				45000	3000	2385
Ozone Generation System	24						0
					2177600	156750	115413

DIRECT LABOR REQUIREMENT	
Floor Lead Person	1
Soil & Wash Room	7
Flatwork/Folding/Finishing	10
Cart Make Up And Delivery	4
Utility Persons	3
Garment Processing	2
TOTAL	27

7 Worked Hours / Day
5 Days Per Week = 1820 Hrs

#/Worked Hour
5,000,000 / (1820 x 27) = 101.75

* Steam is generated by Boiler
which is in Gas Requirement

AVERAGE ANNUAL MAINTENANCE COST AND ACTUAL ANNUAL MAINTENANCE COST AS A PERCENTAGE OF PURCHASE PRICE VS. EQUIPMENT AGE

YEAR	COST (%)	AVG COST (%)
1	0	0
2	3	1.50
3	4	2.33
4	5	3.00
5	6	3.60
6	7	4.17
7	7	4.57
8	7	4.88
9	7	5.11
10	7	5.30
11	7	5.45
12	7	5.58
13	7	5.69
14	7	5.79
15	7	5.87
16	7	5.94
17	7	6.00
18	7	6.06
19	7	6.11
20	7	6.15

The average annual maintenance cost is based on the recorded maintenance costs from several facilities, and several different types of laundry equipment.
The cost does level out at 7% per year at an equipment age of 6 years.

The 10 year average of 5.3% is used in the maintenance cost calculation in the various plant equipment lists.

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